# New Scientist

WHAT WE KNOW ABOUT
LONG COVID, FOUR YEARS ON

WHY CLOCKS CAN NEVER
BE COMPLETELY ACCURATE

DID HOMO NALEDI
REALLY BURY ITS DEAD?

THE BEST SCIENCE
BOOKS OF 2023

**WEEKLY** 2 December 2023

## THE PARTICLE THAT SOLVES THE UNIVERSE

How 'axions' could explain dark matter, dark energy and more

No3467 £6.95 CAN$9.99

Travel Insurance with you in mind

Get immediate cover
**truetraveller.com**
or call **0333 999 3140**
REVIEWS.io
★★★★★

truetraveller
travel insurance designed by travellers

In partnership with AXA

# This week's issue

## On the cover

**32** **The particle that solves the universe**
How 'axions' could explain dark matter, dark energy and more

New Scientist
THE PARTICLE THAT SOLVES THE UNIVERSE
How 'axions' could explain dark matter, dark energy and more

Vol 260 No 3467
Cover image: Colin Reid

**36** **What we know about long covid, four years on**

**10** **Why clocks can never be completely accurate**

**11** **Did *Homo naledi* really bury its dead?**

**28** **The best science books of 2023**

**36 Features**

> **"The incidence of long covid is predicted to reach that of heart disease"**

## News

**8** **Strange materials**
AI has predicted 2 million previously unknown crystals

**12** **Dietary advice**
Being slightly overweight may be healthy for over 65s

**14** **Green machines?**
The facts about carbon dioxide removal technology

## Views

**21** **Comment**
Limiting warming to 2°C is still achievable, says Jakob Thomäe

**22** **The columnist**
Michael Le Page on the return of beavers to the UK

**24** **Aperture**
Life in the dust bowl where the Aral Sea once stood

**26** **Letters**
Ancient migration has lessons for us all, says one reader

**30** **Culture columnist**
Sally Adee selects the hottest sci-fi of the year

SHUTTERSTOCK/JOEPRACHATREE

**28** **Close reading** The year's best science books and photobooks

## Features

**32** **Wonder axions**
A resurgent particle named after a soap detergent could solve the biggest mysteries in the cosmos

**36** **Lingering symptoms**
Have we finally got a handle on the complexities of long covid?

**40** **True cost accounting**
How to factor in the social and environmental damage of everything that we buy

## The back pages

**44** **Mathematics of life**
How to use maths to ensure your presents are beautifully wrapped

**45** **Puzzles**
Try our crossword, quick quiz and logic puzzle

**46** ***Almost* the last word**
What is the shortest parking space a car could get into?

**47** **Tom Gauld for *New Scientist***
A cartoonist's take on the world

**48** **Feedback**
Not so clap happy, plus stepping tech and disco stars

# Elsewhere on New Scientist

## Virtual event

### The best of *New Scientist* 2023

Hear *New Scientist* journalists review the biggest stories of the year, reveal their favourite articles of the past 12 months and tell us what their hopes and fears are for science in 2024. This online, subscriber-only event is hosted by our deputy US editor Timothy Revell on 12 December at 6pm GMT.

**newscientist.com/events**

## Tour

### Darwin's Galapagos

Sitting off the coast of Ecuador, this archipelago is a bucket list destination for wildlife buffs – with the possibility of sighting giant tortoises and humpback whales. Travel on a spacious and stylish yacht, accompanied by conservation advocate Jo Ruxton, as you immerse yourself in the islands that served as inspiration for Charles Darwin's theory of evolution. This eight-day tour starts on 26 August 2024 and costs £6999.

**newscientist.com/tours**

## Podcast

### Weekly

The team look to Mercury, where glaciers made of salt could harbour life on the largely inhospitable planet. They also find out how humans may learn language before we are even born. Plus, they talk about a very energetic cosmic ray that appeared to come from a mysteriously empty region of space and a small bat in Europe that uses its penis as a hand.

**newscientist.com/nspod**

ISRO

**Chandrayaan-3** India's rover went to sleep as the moon went dark

SHUTTERSTOCK/FARJANA RAHMAN

**Falklands falcons** Necessity is the mother of avian invention

## Video

### Bright birds

Much of what we know about bird intelligence comes from studies of parrots and corvids. But the striated caracara, a type of falcon that lives on the Falklands Islands, which are surrounded by ocean and strong winds, has had to develop innovative ways to find food too. Ecologist Katie Harrington set up eight puzzle boxes to study how the birds explore and learn.

**youtube.com/newscientist**

## Newsletter

### Launchpad

*New Scientist* physics reporter Leah Crane rounds up the most exciting space stories of 2023, from India's Chandrayaan-3 mission that put a rover on the moon to the European Space Agency's JUICE spacecraft, which is headed for Jupiter's ice moons. Plus, find out what missions to keep an eye on next year.

**newscientist.com/launchpad**

**Podcast**

> "They have named the cosmic ray Amaterasu, after the Japanese Shinto sun goddess"

## Christmas gifts

From our Essential Guide bundle to jigsaw puzzles, new books, stationery sets and socks, get the perfect gift for someone you love this Christmas. Order before 11am on 13 December to guarantee UK delivery before Christmas. Outside the UK? E-gift cards are also available.

**shop.newscientist.com**

edf

We're busy generating more British zero carbon electricity than anyone

Helping keep future energy costs down and cut UK carbon emissions to nothing

Trustpilot

★★★★★

UK Fuel Mix disclosure information, published by the Government Department DESNZ recognises electricity from wind, solar and nuclear fuel produces zero carbon dioxide emissions at the point of generation. For verification visit: www.edfenergy.com/zero-carbon

**Gift subscriptions**

**NewScientist**

**Gifts** *from*
**£54.95**

# Give the gift of knowledge

Give a *New Scientist Essential Guide* subscription to wow friends and family this Christmas. Your recipient will receive all 5 of our beautiful need-to-know compendiums covering the biggest topics in science and technology in 2024, delivered straight to their door. Plus, we'll send you a gift-boxed copy of the upcoming Human Mind issue to give to them before their subscription starts.

**Explore our full range of gift options at**
**newscientist.com/20567**
**or call +44 (0) 330 333 9470, quoting 20567**

**Scan me to sign them up**

For Essential Guide subscriptions, gift box will contain issue 20. Gift boxes only available where both the gift-giver and recipient are in the UK. Order by 11 December to guarantee delivery to meet last Christmas post deadline to send onto recipient within the UK. Order by 18 December to guarantee pre-Christmas delivery to your address. Offer ends 31 December 2023.

# We must go the extra mile

## Renewed political will is vital to help the "forgotten" millions left with long covid

IT HAS been nearly four years since the covid-19 pandemic began, and many of us would love to forget all about it. But there are millions for whom that is impossible. For them, covid-19 still looms large due to lingering symptoms that remain months, even years, after the initial infection.

Thankfully, interest in long covid, as the condition is known, has been high and our understanding of this post-viral disease has advanced rapidly. As we describe in our feature on page 36, researchers are building a detailed picture of how it affects people's health, including impacts on the immune system, gut and blood. This work is pointing towards potential causes – including the possibility that the coronavirus still lurks in some of us long after it stops showing up in blood tests. It is also enabling trials of treatments and preventative measures, several of which are showing real promise.

This represents rapid and tangible progress. It is a far cry from other post-infection conditions. Famously, myalgic encephalomyelitis/chronic fatigue syndrome (ME/CFS) was dismissed for decades: it is now increasingly accepted as a post-infection illness, thanks in part to the massive research efforts around long covid. It is a similar story for a pain disorder called fibromyalgia.

> **"In the US, things look promising, but a package of UK research projects could soon end"**

This groundswell is clearly a positive step for many conditions, but what is less clear is whether political will and funding will be maintained. In the US, things look promising – a large research programme for long covid has more than $1 billion behind it – but in the UK a comprehensive package of research projects launched in 2021 could soon come to a stop.

Across the world, political motivation needs revitalising and policies need to reflect what we have learned so far. This includes the issue of unpaid sick leave (resting during covid-19 infection reduces the risk of developing long covid) and improving indoor air quality to reduce the spread of disease. We may want to put covid to the back of our minds, but there are too many people still suffering its long tail to forget it any time soon. ▮

PUBLISHING & COMMERCIAL

**Commercial and events director** Adrian Newton

**Display advertising**
**Tel** +44 (0)203 615 6456 **Email** displayads@newscientist.com
**Sales director** Justin Viljoen
**Account manager** Mila Gantcheva
**Partnerships account manager** David Allard

**Recruitment advertising**
**Tel** +44 (0)203 615 6458 **Email** nssales@newscientist.com
**Recruitment sales manager** Viren Vadgama
**Key account manager** Deepak Wagjiani

**New Scientist Events**
**Tel** +44 (0)203 615 6554 **Email** live@newscientist.com
**Sales director** Jacqui McCarron
**Sales manager** Maureen Ignacio
**Head of event production** Martin Davies
**Head of product management (Events, Courses & Commercial Projects)** Henry Gomm
**Marketing manager** Emiley Partington
**Events and projects executive** Georgia Peart
**Events and projects coordinator** Gemma Dowie
**Events team assistant** Olivia Abbott

**New Scientist Discovery Tours**
**Director** Kevin Currie
**Senior product manager** Lara Paxton

**Marketing & Data**
**Marketing director** Jo Adams
**Head of campaign marketing** James Nicholson
**Digital marketing manager** Jonathan Schnaider
**Campaign marketing coordinator** Charlotte Weeks
**Head of customer experience** Emma Robinson
**Senior customer experience marketing manager** Esha Bhabuta
**Head of CRM & audience data** Rachael Dunderdale
**Senior email marketing executive** Natalie Valls
**Email marketing executive** Ffion Evans
**Marketing executive** Naomi Edge
**Junior analyst** Hamied Fahim

**Technology & Product**
**Head of strategy and product development** Clarissa Agnew
**Director of strategic programmes and technology** Jennifer Chilton
**Head of engineering** Tom McQuillan
**Senior developer and UX designer** Amardeep Sian
**Senior developers** Maria Moreno Garrido, Piotr Walków
**Lead digital designer and developer** Dan Pudsey
**Front end developer** Damilola Aigoro
**Junior front end developer** Matthew Staines

**Partnerships**
**Consultant Editor** Justin Mullins

NewScientist

**Chief executive** Roland Agambar
**Managing director** Laurence Taylor
**Chief financial officer** Amee Dixon
**Chair** Nina Wright
**Executive assistant** Lorraine Lodge

**Finance & operations**
**Commercial finance manager** Charlotte Lion
**Commercial finance manager** Anna Labuz
**Management accountant** Charlie Robinson
**Commercial management accountant** Alexandra Lewis

**Human resources**
**HR business partner** Purnima Subramaniam

CONTACT US
**newscientist.com/contact**

**General & media enquiries**
**UK Tel**+44 (0)203 615 6500
9 Derry Street, London, W8 5HY
**Australia** 58 Gipps Street, Collingwood, Victoria 3066
**US** 600 Fifth Avenue 7th Floor | NY 10020 | USA

**UK Newsstand**
Marketforce UK Ltd
**Email** mfcommunications@futurenet.com

**Syndication**
Tribune Content Agency **Tel** +44 (0)20 7588 7588
**Email** tca-articlesales@tribpub.com

**Subscriptions**
**newscientist.com/subscription**
**One year print subscription (51 issues) UK £270**
**Tel** +44 (0)330 333 9470
**Email** subscriptions@newscientist.com
**Post** New Scientist, Rockwood House, Perrymount Road, Haywards Heath, West Sussex RH16 3DH

© 2023 New Scientist Ltd, England. New Scientist is published weekly by New Scientist Ltd. ISSN 0262 4079. New Scientist (Online) ISSN 2059 5387. Registered at the Post Office as a newspaper and printed in England by Precision Colour Printing Ltd

EDITORIAL

**Editor-in-chief** Emily Wilson
**Magazine editor** Catherine de Lange
**News and digital director** Penny Sarchet
**Creative director** Craig Mackie

**News**
**News editor** Jacob Aron
**Assistant news editors** Chris Simms, Alexandra Thompson, Sam Wong
**Reporters** (UK) Madeleine Cuff, Michael Le Page, Chen Ly, Matthew Sparkes, Alex Wilkins, Clare Wilson, (Aus) Alice Klein

**Digital**
**Acting head of digital** Matt Hambly
**Podcast editor** Rowan Hooper
**Head of editorial video** David Stock
**SEO and analytics manager** Finn Grant
**Social media manager** Isabel Baldwin
**Trainee video producer** Obomate Briggs

**Features**
**Head of features** Daniel Cossins and Helen Thomson
**Editors** Abigail Beall, Kate Douglas, Alison George, Joshua Howgego, Thomas Lewton, Eleanor Parsons
**Feature writer** Graham Lawton

**Culture and Community**
**Comment and culture editor** Alison Flood
**Senior culture editor** Liz Else

**Subeditors**
**Acting chief subeditor** Tom Campbell
Bethan Ackerley, Tom Leslie, Jon White

**Design**
**Art editor** Ryan Wills
Joe Hetzel

**Picture desk**
**Picture editor** Tim Boddy
**Assistant picture editor** Jenny Quiggin

**Production**
**Production manager** Joanne Keogh
**Production coordinator** Carl Latter

**New Scientist US**
**US Publisher** Tiffany O'Callaghan
**Editors** Timothy Revell, Chelsea Whyte
**Subeditor** Alexis Wnuk
**Deputy audience editor** Gerardo Bandera
**Reporters** Leah Crane, James Dinneen, Jeremy Hsu, Karmela Padavic-Callaghan, Christie Taylor, Grace Wade, Corryn Wetzel

Shop
**NewScientist**

# Perfect Christmas gifts

From our new Essential Guide bundle to puzzles, new books to stationery sets, get the perfect gift for yourself or someone you love this Christmas. E-gift cards are the perfect gift for those hard to buy for. Available in four denominations, an email will be sent immediately after purchase with instructions how to get your gift card code.

**Visit shop.newscientist.com/xmas**

Orders placed before 11am 14 December 23 GMT for delivery in the UK are guaranteed for pre Christmas delivery.
Orders for countries outside of the UK, or UK orders placed after this time, cannot be guaranteed in time for Christmas.

# News

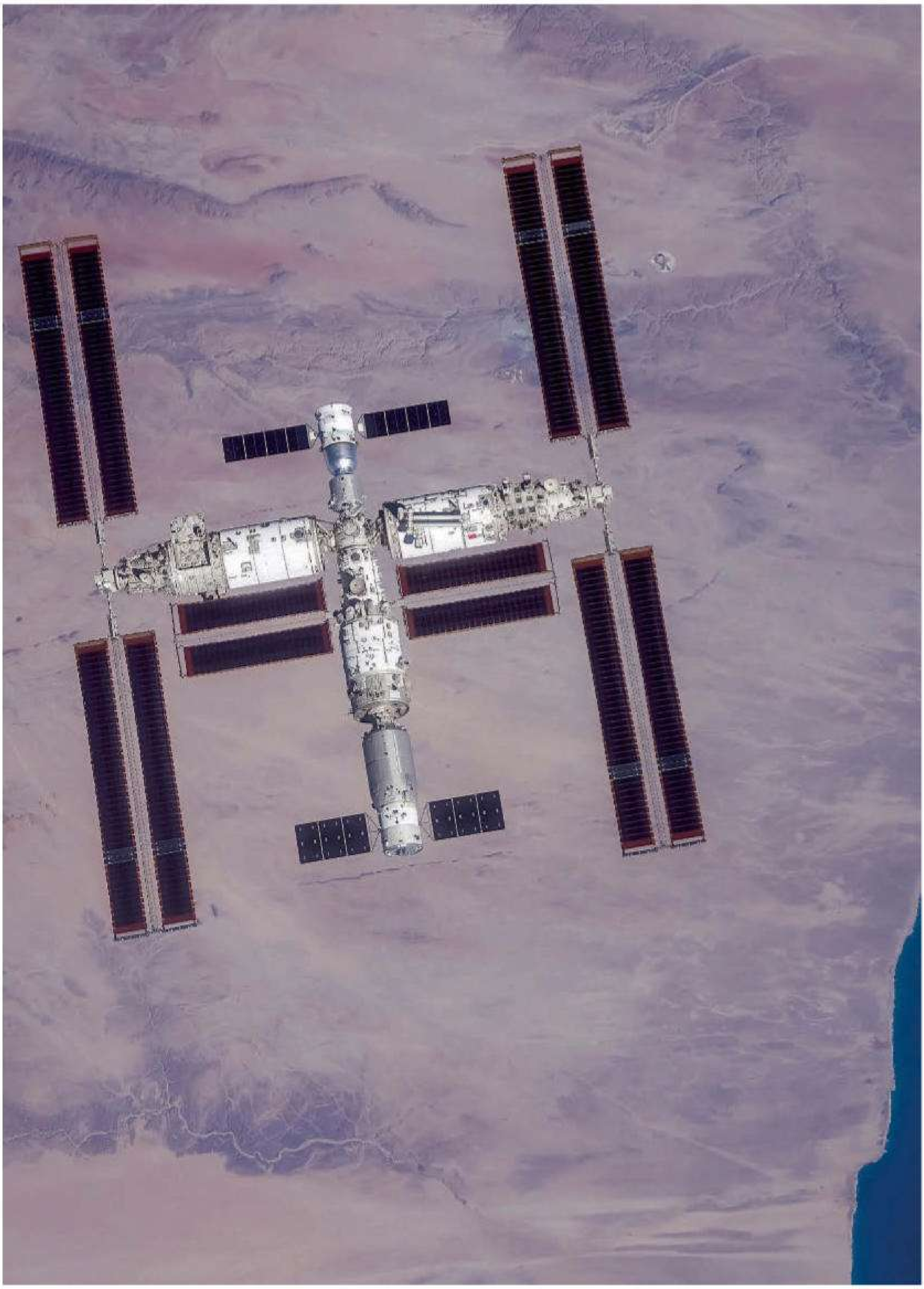
**Longer lives**
Way to estimate lifespan could help us extend it p9

**Earliest supernovae?**
We may have seen hints of the first star explosions p13

**Mystery particle**
Strange high-energy cosmic ray smashes into Earth p16

**Peer-group pressure**
AIs trick each other into doing things they shouldn't p17

**Underground battery**
Old coal mine to be tested for storing wind energy p18



CHINA MANNED SPACE

Space

## Chinese station caught from above

China's Tiangong space station has been photographed in its complete form for the first time. This vertiginous image was taken from the Shenzhou spacecraft as it made its way back to Earth after delivering three crew members to the space station. The Tianhe module, at the centre of the structure, contains astronauts' living quarters. The China Manned Space Agency has approved more than 1000 experiments to be performed in microgravity on the space station, including studying how plants grow and how fluids flow there.

Materials science

# AI could discover wonder materials

We know of about 48,000 inorganic crystal structures, which can give materials a range of properties. Now, an AI from Google DeepMind has predicted millions more, finds **Alex Wilkins**

AN ARTIFICIAL intelligence created by Google DeepMind may help revolutionise materials science, providing new ways to make better batteries, solar panels, computer chips and many more vital technologies.

"Anytime somebody wants to improve their technology, it inevitably includes improving the materials," says Ekin Dogus Cubuk at DeepMind. "We just wanted them to have more options."

The AI model, called Graph Networks for Materials Exploration, or GNoME, is designed to predict inorganic crystal structures, which are repeating arrangements of atoms that provide materials with particular properties – for example, the sixfold symmetry of a snowflake is a result of the crystal structure of ice.

Organic crystals, which include carbon-hydrogen bonds, are well understood because of numerous examples in biological systems, but until now we only knew of around 48,000 possible inorganic crystals.

GNoME has massively expanded that figure to more than 2 million, and while some of these new structures might decay into more stable forms or be impossible to create altogether, more than 700 of the predictions have already been made in the lab.

GNoME is a graph neural network, a kind of AI that can learn the relationships between objects, such as atoms and their chemical bonds. Cubuk and his colleagues trained GNoME on an existing database of known inorganic crystals and used it to generate new possible crystals by changing the elements or playing with the known crystals' symmetries. It also predicted the energies of the new crystals, a measure of their stability.

MARILYN SARGENT/BERKELEY LAB

**A robotic lab created by researchers at the University of California, Berkeley**

The researchers used quantum mechanics simulations to assess the accuracy of these energy predictions, then they fed the results back into GNoME's structure predictions, for a total of six rounds.

"What we saw is that, every round, the model's predictions got better and better for generalising to novel stable crystals," says Cubuk.

Of the 2.2 million predictions, there were 400,000 crystals that were in their most stable form, with no lower-energy form possible. But some less stable crystals, known as metastable crystals, could still be useful. Diamond, a metastable form of carbon, is one example.

**48,000**

**Number of inorganic crystal structures we knew about**

**2 million**

**Approximate number of crystals predicted by Google DeepMind's AI**

**70%**

**Accuracy of the crystal predictions that have been tested so far**

By scanning the scientific literature published after GNoME was developed, ensuring any results found weren't present in its training data, the team discovered that GNoME had predicted more than 700 crystals since produced by other researchers. These include a low-temperature molybdenum superconductor and a diamond-like lithium and magnesium crystal that could be used in high-powered lasers (*Nature*, DOI: 10.1038/s41586-023-06735-9).

DeepMind shared its predictions with Yan Zeng at the University of California, Berkeley, and her colleagues, who are developing a robotic lab capable of autonomously synthesising crystals. The Berkeley team independently predicted 60 crystal structures, of which the automated lab was able to create 41. As GNoME had also predicted these structures, this external verification suggests that its predictions are at least 70 per cent accurate, says Cubuk.

The researchers have now made the entire dataset of predicted crystal structures available to others. "It is going to accelerate discovery of new materials," says Graeme Day at the University of Southampton, UK. "That's the big deal of it – compared to what's been in these databases before, you're able to scale up by an order of magnitude."

These materials could include things like better alloys for cars, improved energy density for solid-state batteries and more effective energy harvesting for solar panels, says Cubuk.

Andy Cooper at the University of Liverpool, UK, also says it will speed up the process of discovering novel materials, but knowing a material's properties, such as its conductivity or ability to store energy, is important too. "Property calculations tend to often be quite expensive," he says. "You know the structure might exist, but if you don't know what it does, then it's not clear whether to make it or not."

For now, the best way to understand a material's properties is to synthesise it, which is a major bottleneck for chemistry, even with the assistance of robotic labs such as the one used by Zeng and her team.

"The world's capability to predict and calculate things, and use machine learning to extrapolate further, is evolving faster than the robotic capability to look for the materials," says Cooper. ■

Ageing

# A new way to estimate maximum lifespan could help us extend it

Michael Le Page

WE MIGHT have found a new way to extend the lifespan of many mammals, including people.

A study of 15,000 tissue samples from 348 mammal species has shown that it is possible to predict their maximum lifespan by looking for the presence or absence of labels known as epigenetic markers at specific sites in the genome. What's more, these could be causal. That is, altering the epigenetic markers might increase maximum lifespans.

"I do think it is quite possible," says Steve Horvath at Altos Labs in Cambridge, UK. Other groups have managed to extend the lifespans of invertebrates such as worms by around a third by making epigenetic changes. "So probably you can change the epigenome one way or another in a mouse and then the mouse will live one or two years longer," says Horvath.

Many of the differences between species aren't due to variations in genes, but differences in how those genes are used – when they get turned on or off, for instance. One important way that genes are regulated is by adding epigenetic markers to DNA, chemical labels that change gene activity without altering the underlying sequence.

A common epigenetic change involves the addition of a small molecule called a methyl group to the DNA letter C, in a process known as methylation. Horvath has led a seven-year project that looked at methylation patterns in up to 60 different tissue types in 348 mammal species. The work was funded by private donors, but the information is freely available.

His team has already shown that the methylation patterns in DNA sequences shared by all mammals can be used to estimate the age of individual animals. Now, the team has used supervised machine learning to find methylation patterns linked with the maximum lifespan of species in sequences shared by all mammals (bioRxiv, doi.org/k6nz).

"If you find a piece of skin or a tail or whatever from a species you know nothing about and you give me that sample, I can tell you the maximum lifespan of the species, the gestation time of the species and the age at sexual maturity," says Horvath. "To me, that's quite remarkable."

These methylation patterns vary somewhat from tissue to tissue and the predicted maximum lifespans are approximate. The method is least accurate for people, predicting a maximum of around 98 years, whereas Jeanne Calment, thought to be the world's longest lived person, made it to 122 years. While Calment's age has been disputed, others are verified as living up to 119.

**Epigenetic markers at specific DNA sites are linked to lifespan**

MARK GARLICK/SCIENCE PHOTO LIBRARY

"We are complete outliers," says Horvath, with our gorilla cousins living to 60 years at most.

For 17 of the 348 species, including humans, females consistently had longer predicted maximum lifespans.

The team also found that lifestyle factors such as caloric restriction or body weight had little effect on predicted maximum lifespans.

"I think it's amazing work," says João Pedro de Magalhães at the University of Birmingham in the UK. He finds it interesting that these methylation sites tend to occur in genes related to development. "Perhaps mice age 20 to 30 times faster than human beings because they develop 20 to 30 times faster than human beings," he says.

"Whether this link between epigenetic signatures and lifespan is causal is the big question," he says. "My intuition is that some of these epigenetic signatures are indeed reflective of causal processes." ▮

---

Astrophysics

# Odd way black holes lose energy may solve cosmic puzzle

**BLACK holes across the universe are losing enormous amounts of energy, and it could be due to magnetic fields slowing their spin.**

**A new study of the supermassive black hole M87* has shown that the energy near its edge is flowing outwards, not falling in. People have long theorised that the magnetic fields of spinning black holes extract energy from their parent objects to power the jets they launch across the universe at nearly the speed of light.**

**To investigate how black holes do it, Andrew Chael at Princeton University and his colleagues used data from the Event Horizon Telescope (EHT) to examine energy flows near M87*.**

**"The power of the jet coming from M87* is at minimum thought to be $10^{42}$ ergs per second, which is 250 million times the sun's total luminosity – that's the same power as 3000 TNT bombs, each with the same mass as Earth, detonated every second," says Chael.**

**This energy can't be coming from within the black hole, as everything that crosses its event horizon is trapped. That means it must come either from the black hole's rotation or from the disc of hot plasma falling into the black hole. The EHT data seems to support the former idea, showing energy streaming away from close to M87*'s edge (*The Astrophysical Journal*, doi.org/k6jm). The researchers say this may be due to magnetic fields threaded through the black hole.**

"That's the same power as 3000 TNT bombs, each the same mass as Earth, detonated every second"

**The process is a bit like twirling a spinning top with strings attached to its edges. "The magnetic fields are what is extracting the energy from the spin of the black hole – they're being wound up and sort of torquing the black hole back down," says Chael. "Because it's just the rotational energy that's being extracted, not the mass, it doesn't break any laws of physics."**

**Black hole jets move energy out from the centres of galaxies, so understanding them helps us work out how galaxies evolve.** ▮

Leah Crane

Time

# Physicists find ultimate limit for how accurate clocks can be

Alex Wilkins

THERE is a fundamental trade-off between making a clock accurate and counting ever shorter ticks, due to the second law of thermodynamics. This could one day be important for quantum computers.

A common way of expressing the second law of thermodynamics is that the amount of disorder in a system (its entropy) must always increase over time. As a consequence of this, there is an arrow of time. All physical laws we know of would be the same if time were reversed, says Marcus Huber at the Vienna University of Technology in Austria, "so we wouldn't be able to tell time, but there's one exception and this is the second law of thermodynamics".

He and his colleagues realised that an idealised clock would also be subject to this second law and would need to generate disorder to tick. "Entropy needs to be produced for time to be measured, but does this mean the more I know about the time passed, or the more accurately I can tell time, the more entropy I need to produce?" says Huber.

FLASHMOVIE/GETTY IMAGES

**The more precisely we measure time, the harder it is to get the time right**

In an earlier study, they proved that more accurate clocks must produce more entropy, but they didn't yet know how this related to how often the clock ticks, known as its resolution.

To answer this question and see how accuracy, entropy and resolution are related, Huber and his team realised they needed a better definition of what a clock is, in thermodynamic terms. They concluded that a clock needs a system that can "tick" in an irreversible and random way, but it also requires another system to count this ticking.

One way of illustrating this is with a sand-filled hourglass that drops grains of sand through a hole. The ticks are counted by watching for when there are no grains left in the top half. A 10-minute sand timer is accurate at measuring a 10-minute period, but you can't use it to measure shorter intervals, so it has a very low resolution.

If you could count each individual grain that goes through the hole, you would get a higher resolution, but it wouldn't be very accurate because the randomness in the system means the grains don't go through at regular intervals.

> "A clock needs a system that can tick, but it also requires another system to count this ticking"

This is an inherent property of all clocks, Huber and his team found. By examining this relationship using quantum mechanics and thermodynamics, they proved that the resolution, defined as how frequently a clock can tick, is equal to the inverse of its accuracy squared, where accuracy is the number of times it can tick before being off by one tick (arXiv, doi.org/k6nv).

This limit isn't relevant for the most accurate clocks today, such as atomic clocks, because they only measure things at a resolution of around a second, but it could apply to future quantum computers because they will need extremely fine timescales and high accuracy, says Huber. ▮

---

Technology

# Robots with spongy paws could navigate uneven terrain

**GIVING robots squidgy paws that contain cameras could help them negotiate their steps better.**

**Tejal Barnwal at the Indian Institute of Technology Bombay, Jørgen Anker Olsen at the Norwegian University of Science and Technology and their colleagues have developed what they call a Terrain Recognition and Contact Force Estimation Paw (TRACEPaw).**

**The bottom part of the foot is half a silicone ball, which deforms as the robot walks. Inside the ball, a 2-megapixel camera takes images of a grid-like pattern of dots on the interior of the silicone, detecting how it changes in response to each step. The images are sent to an internal artificial intelligence model, which works out what force is being applied and from what direction.**

**A microphone captures the sound made by each step, which another AI model uses to differentiate between surfaces and give the robot more data on what it is treading on (arXiv, doi.org/k6h8). "If you can detect the soil type and then give this information to the robot, it can adjust the way it walks, just as you would walk differently if you walked on concrete, gravel or sand, or ice," says Olsen.**

JØRGEN ANKER OLSEN

The TRACEPaw foot contains a camera that analyses what is being stepped on

**A small computer chip inside the foot can run all the AI algorithms, so extensive wiring isn't needed throughout the robot. The entire electronics package costs about £100 and is about the size of a £1 coin, but just 1 millimetre thick.**

**To do the same thing, a robot would conventionally use a range of force and torque sensors. In tests, the researchers found that TRACEPaw was almost as accurate as force and torque sensors, but crucially cheaper and less bulky.** ▮

Matthew Sparkes

# Did *Homo naledi* bury its dead?

Earlier this year, researchers claimed that extinct hominin *Homo naledi* buried its dead and produced rock art, but now others say the evidence is "non-existent", finds **Michael Marshall**

THE much-publicised claim that a species of small-brained ancient human buried its dead and produced rock art is completely unfounded, according to a group of researchers.

"The evidence for burial and rock art is non-existent," says Michael Petraglia at Griffith University in Nathan, Australia.

However, the researchers behind the original claim say they are hard at work gathering more evidence to build their case. They also contend that their studies are caught up in a wider debate over how scientific results should be published and critiqued.

The controversy centres on the extinct hominin *Homo naledi*, which was first described in 2015 by researchers led by Lee Berger at the University of the Witwatersrand in Johannesburg, South Africa. They had found hundreds of bones in the Rising Star cave system in South Africa, which is difficult to access due to its narrow passages.

*H. naledi* lived about 250,000 years ago. That makes it a contemporary of our species, *Homo sapiens*, as well as other recent, large-brained hominins like the Neanderthals. However, *H. naledi* had a small brain typical of much earlier hominins. Despite this, Berger's team has argued over the years that *H. naledi* used controlled fire to light its way in the pitch-black caves, and that it placed a child's skull on an inaccessible ledge – perhaps as part of a funerary rite.

In June, the researchers released three linked papers, initially on the bioRxiv research server, and a few days later in the journal *eLife*. In these papers and at an accompanying press conference, they claimed to have evidence of the deliberate burial of corpses in sediments and of engravings carved into cave walls. This was surprising because small-brained hominins like *H. naledi* weren't thought to be capable of such symbolic or ritualistic behaviours. Many palaeoanthropologists were publicly sceptical.

## Natural processes

"There is a lack of evidence for the interment of a body in an intentional grave pit," says Petraglia. Instead, the bones could have been naturally accumulated. He and his colleagues have published a paper critiquing Berger's team's claims, in which they also argue the purported engravings could be the result of natural erosion processes (*Journal of Human Evolution*, doi.org/k6jf).

The controversy is partly about the way the research was published. Traditionally, scientific journals send papers to other scientists who supply confidential peer reviews. The journal normally only publishes the studies if the peer reviews are positive. However, *eLife* is pioneering an alternative model. The journal publishes studies immediately and releases the peer reviews alongside them.

"The *eLife* review process is totally transparent," says John Hawks at the University of Wisconsin-Madison, one of the authors of the June papers. He argues that traditional peer review is open to manipulation because it is confidential.

The *eLife* peer reviews for these three papers were strongly negative. The reviewers described the studies as "incomplete" and "inadequate", arguing that the evidence wasn't sufficient to support the claims.

Petraglia wants the team to withdraw the papers, if possible, and bring in more people. "I would recommend forming a strong, multidisciplinary scientific team composed of geologists, stratigraphers, geochronologists, biological anthropologists who study burial, and rock art experts," he says. He also wants to see "a strategy for doing proper scientific research".

Hawks says the team is working to address the reviewers' concerns, including by supplying additional data and by highlighting previous observations that bolster its case. "I can tell you that having the reviews that we have is going to make final papers that are much stronger and much better," he says. "That's the way that the scientific review process is supposed to work. I don't think there's anything any different about it here, other than that the public can watch."

**"Small-brained hominins like *H. naledi* weren't thought to be capable of such symbolic behaviours"**

A further complication was that the *H. naledi* researchers allowed film-makers to follow them as they explored the caves. The result was the Netflix documentary *Unknown: Cave of Bones*, released in July, which showcased the burial and rock art claims. Petraglia argues this was "premature and irresponsible" because the work hadn't been peer-reviewed.

"People should be aware that scientists do not have editorial control over documentaries," says Hawks. He argues it is all part of their attempts to be transparent. "In this case, we were able to allow cameras and journalists to be present in our work. And it happens that we made some interesting discoveries."

Hawks and his colleagues were invited to submit a response to Petraglia's paper, but only once it was peer-reviewed and about to be published. They have drafted their response, but it hasn't yet been peer-reviewed, so the journal asked them not to share it with *New Scientist*.

PETER VAN EVERT/ALAMY

***Homo naledi* coexisted with *Homo sapiens*, but had a smaller brain**

**Analysis** **Dietary guidance**

# Is it healthy for older people to be slightly overweight?

UK dietitians say people over 65 need greater fat reserves. Why are they contradicting most other guidelines, asks **Clare Wilson**

THE usual healthy weight advice has been torn up for people who are over 65, at least in the UK. People in this age group are now being told that "if you are slightly overweight, losing weight might not actually improve your health", in the latest advice from the British Dietetic Association (BDA).

While the version of the guidance aimed at the public doesn't mention body mass index (BMI), which divides someone's weight in kilograms by the square of their height in metres, a report of supporting evidence cites studies that found the optimum BMI for older people is about 25 to 30 kg/m². That is in contrast to most advice, which recommends that adults of all ages aim for a BMI of between 18.5 and 25.

"I don't think older people particularly focus on their BMI, but healthcare staff can be a bit obsessive about it," says Alison Smith at the BDA. "It's not unusual to see people in their 80s who have BMI of 28 [being] told to lose weight."

There are several reasons for people to aim for a higher weight as they get older, she says. One is that fat acts as an energy store that can be drawn on when people get ill and lose their appetite.

"Periods of ill health increase as you age," says Smith. "By encouraging older adults to lose weight, you're almost making them less resilient."

Another is that weight loss tends to cause loss of both fat tissue and muscle, with the latter raising the risk of falls and ill health. Muscle mass already tends to decline naturally with age, a process called sarcopenia.

A third factor is that people who go on a diet may become tired and less likely to stay physically active, which can further contribute to muscle loss.

NIK TAYLOR/ALAMY

**Older people shouldn't necessarily limit treat foods, such as ice cream**

"It's better to stay fit and not worry so much about excess weight than to reach this arbitrary target of a BMI of 25," says Mary Hickson at the University of Plymouth, UK, a co-author of the BDA report.

Additionally, those who care for older people and are aware of general healthy eating advice may buy them low-fat foods and avoid treats such as ice cream without considering if the person does, in fact, need to lose weight.

**25-30**

**The new report's suggested optimum BMI for over 65s**

This can lessen older people's enjoyment of their food, says Hickson. "If you're too restrictive, it can reduce the amount of pleasure people have [in eating]. Worrying about your cholesterol and saturated fat when you're 85 probably isn't the best approach."

The advice for adults of all ages to aim for a BMI of under 25 is common in most countries, but it isn't based on clear evidence. It seems to have entered the medical orthodoxy at a meeting of the World Health Organization in 1997.

In fact, population studies give varying estimates for the BMI range linked with the lowest rates of death, with most suggesting the optimum value is in the 25 to 30 band, for all ages. The strongest evidence that a higher BMI is preferable comes from studies of older adults.

The new approach to weight advice for older people chimes with the latest view from the National Institute for Health and Care Excellence (NICE), a medical guidelines body in England.

Its advice on obesity management, updated in July, says healthcare staff should interpret BMI "with caution in people aged 65 and over, taking into account... the possible protective effect of having a slightly higher BMI when older".

Katherine Flegal at Stanford University in California, who has long argued that the standard BMI categories are too low for all age groups, says these stances are a "good start". ▮

---

**Technology**

# 'Insect-eye' compass navigates by the sun even on cloudy days

**Alex Wilkins**

**A COMPASS that relies on polarised light can use the sun to tell where magnetic north is, even when it is cloudy. It is based on how some insects navigate and could be used when conventional magnetic compasses aren't reliable.**

**Insects like ants and bees can sense direction using sunlight's intensity and its polarisation, a measure of how light rays can appear twisted, using receptors arranged in a ring in their eyes.**

**This lets them use the sun as a reference point, like a magnetic compass pointing to the north pole. It works even on a cloudy day, because polarisation can still be detected in these conditions.**

**Evripidis Gkanias at the University of Edinburgh, UK, and his colleagues have built a version from eight light receptors arranged in a ring that mimics how insects' eyes measure polarised light.**

**Daylight is most polarised at 90 degrees from an observer's line-of-sight to the sun, so by measuring this polarisation and the brightness of the light, the researchers could use a computer algorithm to find the sun's position.**

**The researchers tested the compass on a wheeled robot in Italy and South Africa, in the same kind of habitats that desert ants and dung beetles experience. They found it could track the sun's position relatively accurately, but because of problems lining up the robot with magnetic north at the start, the sensor was less accurate than they had predicted (*Nature Communications*, doi.org/k6nf). Correcting for this error would have made it better than other compasses that detect polarised light, says Gkanias.**

**The device could be useful when magnetic compasses don't work, such as on drones, whose rotors generate interfering magnetic fields of their own, he says. ▮**

**Astronomy**

# Earliest supernovae spotted?

The James Webb Space Telescope may have glimpsed the explosions of the earliest stars

**Alex Wilkins**

WE MAY have spotted the remnants of the very first supernovae in the universe, a chemical fingerprint of the earliest stars and the start of a process that eventually created almost every element in the periodic table as well as the "stardust" that makes up our bodies.

When stars formed after the big bang, they contained mostly just hydrogen and helium. As these first-generation stars, known as population III stars, reached the end of their life, they exploded in supernovae, producing heavier elements that were incorporated into a new generation of stars.

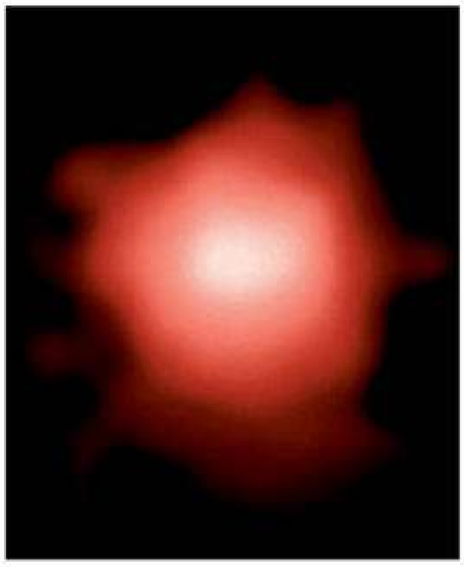
Astronomers haven't been able to observe these ancient stars or their explosions directly, as they would have been born and died just a couple of hundred million years after the big bang.

Instead, Roberto Maiolino at the University of Cambridge and his colleagues have used the James Webb Space Telescope (JWST) to study one of the earliest galaxies ever seen, GLASS-z12, for more than 50 hours. The galaxy, which was born 350 million years after the big bang, was itself spotted using JWST last year.

By analysing the light from the galaxy, the team found it contained carbon, and there were weaker detections of elements like oxygen and neon too. "This is the most distant signature of any heavy element in the universe, which is remarkable," says Maiolino.

The team focused on the ratio of carbon and oxygen within the galaxy because it can tell us what stellar processes are happening. The ratio tends to decrease in galaxies as we look back further in the universe, as there has been less time for stars to repeatedly explode and "pollute" their galaxies with carbon. But oddly, GLASS-z12's carbon-to-oxygen ratio was higher than in many newer galaxies (arXiv, doi.org/k6nq).

**The galaxy GLASS-z12 shows signs of the earliest supernovae in the universe**



NAIDU ET AL, P. OESCH, T. TREU, GLASS-JWST, NASA/CSA/ESA/STSCI

It isn't clear what is producing this carbon, but the brief time the galaxy has existed for and its high mass rule out many scenarios, such as regular supernovae from stars like our sun, says Maiolino. One of the few mechanisms that could explain this pattern, he says, is exploding population III stars, which are low-energy and extremely pure in hydrogen and helium, allowing them to produce more carbon than other stars.

If this is the correct explanation, the observation could give us our earliest glimpse of the stellar process that created nearly all of the elements, even without seeing the population III stars directly. "The universe gets polluted astonishingly quickly," says Emma Chapman at Imperial College London, as just one population III supernova is enough for less-pristine stars to start forming. "It really is just a blink of an eye that they're trying to capture."

Finding out more about GLASS-z12 might be tricky because there is only so much of JWST's time that can be devoted to a single object and this galaxy is now comparatively well studied, says Maiolino. But finding other similarly old galaxies and measuring their carbon ratios could also help shed light on population III stars, he says.

The detection of high levels of carbon in such an old galaxy is surprising, says Richard Ellis at University College London, but uncertainty in both the carbon and oxygen ratio measurement and models of population III stellar explosions means there might be other explanations from different kinds of stars. "We have no idea what a population III supernova would look like, it might not even be like a supernova that we see in the nearby universe," says Ellis. ▮

---

**Technology**

## AI deduces sewing pattern from a photo of clothing

**ARTIFICIAL intelligence can turn a single photo of an item of clothing being worn into accurate sewing patterns to recreate the garment.**

**Clothing makers use sewing patterns to create the differently shaped pieces of material that form a garment, using them as templates to cut and sew fabric. Reproducing a pattern from an existing garment can be a time-consuming task, so Xiangyu Xu at Sea AI Lab in Singapore and his colleagues have instead turned to AI.**

**The team trained an AI model on 1 million images of people wearing items of clothing and the associated sewing patterns known to be of the same piece of clothing.**

**The researchers then created a two-stage AI system called Sewformer that could look at images of clothes it hadn't seen before, figure out how to disassemble them into their constituent parts and predict where to stitch them to form a garment.**

**In tests, Sewformer was able to recreate the original sewing patterns with 95.7 per cent accuracy (arXiv, doi.org/k6jp).**

**"The first most important application will be in virtual reality or the metaverse," says Xu, who wants the technology to be able to recreate digital versions of clothes people see and wear in real life. But he also hopes that it can be useful in the real world. "You could very easily design a garment by taking a picture of someone," he says. "That will help garment manufacturing factories."**

**"You could very easily design a garment by taking a picture of someone"**

**But others have expressed concern about the AI model. "Whether this tactile knowledge could be reproduced to the same quality and accuracy could be challenged," says Alana James at Northumbria University in Newcastle, UK. She also worries that the research raises ethical questions about digitising highly skilled roles in the fashion industry, such as pattern cutters. ▮**

**Chris Stokel-Walker**

**Climate change**

# Saviour or sinner?

Carbon dioxide removal tech, once seen as an impractical and unhelpful distraction amid efforts to cut emissions, now has big money backing it. Will it pay off, asks **James Dinneen**

WHAT do Microsoft, Ikea and Shopify have in common? All have promised to become "carbon negative" companies, aiming to not only cut their emissions, but go beyond that to remove carbon dioxide from the air. With such pledges becoming increasingly popular as boardrooms flex their green credentials, the carbon dioxide removal (CDR) industry is seeing an investment boom.

At the moment, around 2 billion additional tonnes of $CO_2$ are taken out of the atmosphere each year, over and above existing carbon sinks, but this is almost entirely due to efforts to expand forests or other nature-based approaches. To keep emissions in line with the Paris Agreement goal of staying below 1.5°C of warming, the Intergovernmental Panel on Climate Change (IPCC) estimates we need to be removing between another 5 to 16 gigatonnes a year by 2050, depending on emissions reductions elsewhere.

CDR technologies, which can store $CO_2$ for longer periods and may be able to scale up more quickly than nature-based approaches, have the potential to close that gap. But to date, they have removed only around 115,000 tonnes of $CO_2$ (see "A slow start", right).

As nations assemble this week for the COP28 climate summit in Dubai, United Arab Emirates, any steps towards net-zero emissions should be welcomed. But the question remains whether big bets on CDR technology will pay off in time – and will do so without detracting from efforts to directly slash emissions by transitioning away from fossil fuels. Gregory Nemet at the University of Wisconsin-Madison calls this the "formative phase" for CDR, where ideas that worked in the lab are put to the test in the real world. "Inevitably, it's a messy period."

HEIRLOOM CARBON/HANDOUT VIA REUTERS

**A direct air capture plant operated by Heirloom in California**

There are a slew of CDR technologies, but two are likely to dominate: bioenergy with carbon capture and storage (BECCS) and direct air capture (DAC). The former involves growing plants to absorb $CO_2$ from the atmosphere, and then burning them for energy while capturing the resulting $CO_2$ emissions. The latter sees air blown over materials that absorb $CO_2$, then release it when heated. The stream of $CO_2$ from either approach can then be stored underground, turned into rock or locked away by using it in any number of products, from concrete to condoms.

Other engineered approaches use chemicals to remove $CO_2$ from seawater, which naturally absorbs the gas from the atmosphere. Yet others involve grinding up rocks to spread on fields to absorb $CO_2$, or removing carbon taken in by plants by using them to make charcoal and adding this to soil, or sinking wood and seaweed to the bottom of the ocean. There are variations on all of these themes. California-based company Charm Industrial, for instance, uses heat to turn agricultural waste into oil that it then pumps underground.

None of these methods has yet been used to remove more than a few thousand tonnes of $CO_2$, but all have their sights set on billions. Proponents, however, are less clear on the downsides, such as cost, steep energy and land-use requirements and potential consequences for people and ecosystems. Much of the hype around these technologies fails to recognise "how difficult CDR is and how ineffectual it's been", says David Ho at the University of Hawai'i at Mānoa. "We haven't shown that we can do this."

**"I find it a little bit risky to hang our hat on people just stopping emissions to get us to net zero"**

Ho reflects a widely-held view that sees CDR as a false solution, promising a way to keep emitting without the consequences, all while diverting financial and energy resources that could go directly to reducing emissions. He sees the need for large-scale CDR eventually, but says removals now, when the world continues to emit so much $CO_2$, are futile. "Right now, the most valuable thing about CDR is greenwashing," he says.

But others, including Nemet, argue that we have to begin aggressively scaling up CDR now to ensure there is sufficient capacity to meet net-zero targets come mid-century. While many people say relying on removals to hit these targets is a gamble, Nemet sees it the other way. "I find it a little bit risky to hang our hat on people just stopping emissions," he says.

Either way, it is now the consensus view that a substantial amount of CDR will be needed to meet climate targets. According to the IPCC, CDR is “unavoidable” if we are to reach net-zero emissions. But it says those removals are primarily needed to “counterbalance” the residual emissions left in sectors that are difficult to decarbonise, like steel-making or long-distance aviation, and to address any overshoot of our dwindling carbon budget. They shouldn’t be seen as a general solution for every industry or as an excuse to keep emitting, says the IPCC.

“We can’t be relying too heavily on this because we don’t really know today how much we can be removing,” says Eli Mitchell-Larson at the think tank Carbon Gap, emphasising the importance of cutting emissions before resorting to the much more difficult task of removing them.

## Mass removals

Even in an optimistic scenario where efficiency gains lower demand for energy, the IPCC says a total of 20 gigatonnes of $CO_2$ must be removed by the end of the century to meet climate targets. In a more pessimistic scenario, 660 gigatonnes of removals are required. In a middle scenario, we would need a 540-fold increase in removals from new CDR technologies by 2030, and a 1300-fold increase by the middle of the century, according to modelling by Nemet and his colleagues.

Whether this scale is achievable is a question for the future. Today, CDR projects are only just getting started. In November, the first commercial DAC plant in the US started operations in California. Heirloom, the firm behind it, says it will remove 1000 tonnes of $CO_2$ a year, equivalent to the annual emissions from around 200 cars. Meanwhile, a giant DAC plant being built in Texas is supposed to be able to remove half a million tonnes of $CO_2$ a year.

Record amounts of money are also flowing. A consortium of tech giants called Frontier has pledged to buy more than a billion dollars worth of such carbon dioxide removal and recently made its first purchase. Firms that want to green themselves pay CDR outfits per tonne of carbon removed, a bit like carbon offsetting. Leading bank J.P. Morgan has said it would invest $200 million in CDR technology. The US Department of Energy too announced a programme to pay firms tens of millions of dollars in return for carbon removals, and has billions of dollars of support to develop regional DAC hubs. All this amounts to a more than four-fold jump in purchases of new CDR since 2022, which would equate to 5 million tonnes of removals, according to the website CDR.fyi.

But this rush of money is no guarantee that $CO_2$ actually leaves the atmosphere. Only about 2.3 per cent of tonnes purchased so far have been removed. The rest may be delayed or never happen, either because the technologies involved don’t work as planned or upstart companies fold. Mitchell-Larson says the problem is exacerbated by an “inadequate” system to monitor and track removals. He says the system is a bit like “students marking their own homework”.

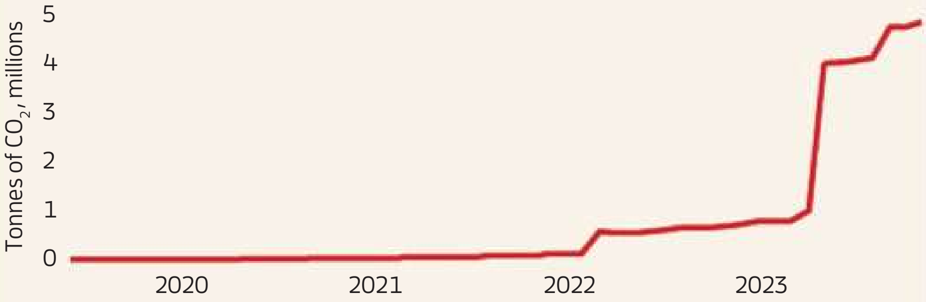
> **“The question that everyone’s asking is: ‘Where is the next billion dollars?’”**

But Mitchell-Larson and others also say potentially risky purchases are needed to spur innovation. “There will be failures in the years ahead,” says Harris Cohn at Charm Industrial. “But there should be if the market is experimenting as aggressively as we need [in order] to grow.” According to its website, Charm has delivered 6417 tonnes of the more than 165,000 tonnes of removals it has sold so far.

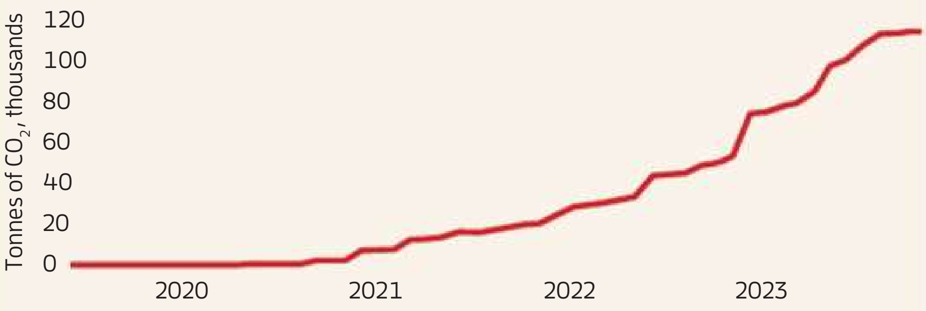
## A slow start

Carbon dioxide removal technology firms have ramped up sales of their services in recent years. Such purchases would amount to removing almost 5 million tonnes of $CO_2$ from the atmosphere, if fulfilled. Actual removals so far lag far behind though, standing at just over 115,000 tonnes, or around 2.3 per cent of what has been paid for

**Total sales**



**Total $CO_2$ removed**



SOURCE: CDR.FYI

Despite concerns over delivery, demand for long-lasting removals doesn’t seem to be flagging. A report from consulting firm BCG, also a buyer of carbon removals, forecasts demand outpacing supply at least to 2030, with the former reaching as much as 900 million tonnes of $CO_2$ per year by 2040 as cost falls and governments do more to support CDR. However, even if CDR firms deliver this, it would leave removals billions of tonnes short of what the IPCC says is needed by 2050.

Mitchell-Larson says closing that gap will require governments to buy removals themselves or force companies to pay for CDR, perhaps via a carbon tax, rather than leaving it to the generosity of climate-conscious firms with lots of extra cash. “The question that everyone is asking is: ‘Where is the next billion dollars?’” he says.

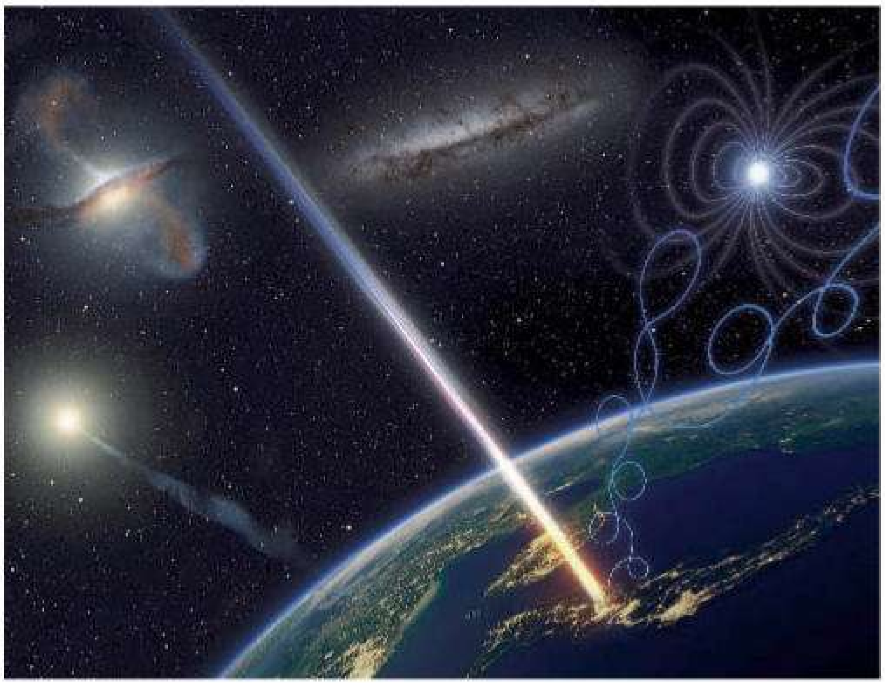
Such issues are set to be discussed at COP28, where CDR is likely to get more attention than before. Currently, the technologies don’t play a big role in any nation’s formal climate commitments, but that could change, says Mitchell-Larson. The summit may also lead to a deal enabling states to trade removals between themselves.

“I think the CDR community is looking for a sense of legitimacy,” says Nemet, to be seen alongside other key climate industries like wind and solar, which also once looked impossibly expensive to build at scale, he says. “We have gone that fast before.” ▮

Physics

# Mysterious high-energy cosmic ray smashes into Earth

Alex Wilkins



OCUIL-INSIGHT, KYOTO UNIVERSITY/RYUUNOSUKE TAKESHIGE

Illustration of an ultra-high-energy cosmic ray hitting our planet

ASTRONOMERS have detected the second most powerful cosmic ray ever recorded, but it seems to have come from an empty region of the universe known as a cosmic void, where there is nothing obvious it could have originated from.

This mysterious cosmic ray, which is probably a charged particle nucleus of some variety, such as of carbon or oxygen, has been dubbed Amaterasu after the Japanese sun goddess.

Possible explanations for it include magnetic fields steering the particle off course, an invisible source in another galaxy or a novel particle.

"The first time I saw the result, I thought that it should be some mistake," says Toshihiro Fujii at Osaka Metropolitan University in Japan. "I thought it was a bit unlucky as it had no source, but actually it is lucky, because we found a new mystery."

Fujii and his colleagues spotted the event using the Telescope Array in Utah, which has more than 500 sensors that can detect showers of particles raining down from extremely energetic particle collisions with Earth's atmosphere. By working back from detections using particle physics models, researchers can reconstruct the energy and direction of an incoming particle.

On 27 May 2021, a group of the sensors lit up with signals that implied a particle had exploded above them with an energy of about 244 exaelectronvolts (EeV), equivalent to the energy of a tennis ball moving at nearly 100 kilometres per hour, squeezed into an atomic-sized object (*Science*, doi.org/k579).

**244**

**The energy of the strange particle in exaelectronvolts**

Events at this energy are rare, with only four recorded above 200 EeV. The most energetic one, a 320 EeV particle called the "Oh-My-God particle", still isn't fully explained.

Ultra-high-energy cosmic rays are thought to be produced in exotic astrophysical events, such as in supermassive black holes or gamma ray bursts. But when Fujii and his colleagues examined the part of the sky the particle had come from, they could see no obvious source.

It is possible the cosmic ray came from somewhere else and veered off course because of the effect of an object's magnetic fields, but with the particle still having such a high energy on arrival, this change of direction can only have been minimal, unless our models of extragalactic magnetic fields are incorrect, says Fujii.

The higher the charge of the particle nucleus, the bigger the deflection, but even the maximum deflection, which would come from a highly charged iron nucleus, doesn't provide a change in trajectory that leads to a possible source.

Higher-energy particles lose energy when interacting with the cosmic microwave background (CMB), radiation left over from the big bang. This limits how far the rays can travel, but if the charged particle is a more exotic phenomenon that doesn't interact with the CMB, it could have come from much more distant galaxies that we can't detect, says Fujii.

It is puzzling, says Justin Bray at the University of Manchester, UK, partly because we have few examples of high-energy cosmic rays and they have been detected in different ways. This makes it hard to analyse them as a group. Although differentiating between possible sources for Amaterasu is tricky, says Bray, claims of a new particle would require extraordinary evidence. "It is a fairly out-there possibility, but, of course, very exciting if true." ▮

---

Medicine

# Lack of sleep before surgery may mean a painful recovery

Grace Wade

NOT getting enough sleep prior to having surgery may increase postoperative pain. This suggests that improvements in recovery time may require good sleep before, as well as after, going under the knife.

Maíra Bicca at Johns Hopkins University in Maryland and her colleagues have studied mice to see how sleep affects the healing process. They used distractions to stop six mice from falling asleep for 9 hours, then gave them an anaesthetic and made an incision in the rodents' hind paws before stitching the wound closed.

For the next two weeks, the team measured each mouse's pain daily by stroking nylon fibres against the wound, seeing how much force was needed before the animal retracted its paw.

Five days after surgery, mice that had been sleep deprived showed greater sensitivity to pain than an equal number of animals who slept sufficiently. For instance, two weeks post-operation, 50 per cent more pressure was needed to make the well-rested animals retract their paws than was needed to make the sleep-deprived mice do so, Bicca told a recent meeting of the Society for Neuroscience in Washington DC.

The sleep-deprived mice also had more inflammatory cells at the site of their incision. This suggests that lack of sleep impairs the immune system's ability to resolve inflammation, which is our body's first line of defence against injury or illness, says Bicca.

Whether the findings will apply to humans is unclear, says Jianguo Cheng at Cleveland Clinic in Ohio. It is possible, though, given known links between sleep, inflammation and pain in us, he says.

To improve surgical outcomes, it might be helpful for healthcare facilities to minimise sleep disruptions, such as noise and light, before surgery, says Cheng. ▮

**Technology**

# AIs can trick each other into doing things they aren't supposed to

**Matthew Sparkes**

ARTIFICIAL intelligence models can trick each other into disobeying their creators and providing banned instructions for making methamphetamine, building a bomb or laundering money, suggesting that averting such AI "jailbreaks" is more difficult than it seems.

Many publicly available large language models (LLMs), such as ChatGPT, have hard-coded rules that aim to prevent them from exhibiting racist or sexist bias, or answering questions with illegal or problematic answers – things they have learned from humans via training data scraped from the internet. But that hasn't stopped people from finding carefully designed prompts that circumvent these protections, known as "jailbreaks", making AI models disobey the rules.

Now, Arush Tagade at Leap Laboratories and his colleagues have found a streamlined process for discovering jailbreaks. They found that they could simply instruct one LLM to convince other models, such as GPT-4 and Anthropic's Claude 2, to adopt a persona that is able to answer questions the base model has been programmed to refuse. This process, which the team calls "persona modulation", involves the models conversing, with humans in the loop to analyse these responses.

> "If you're forcing your model to be good, it implicitly understands what a bad persona is"

To assess the approach, the team asked each AI a variety of questions designed to prompt responses from one of 43 categories, including supporting child labour, helping with illegal activities and promoting homophobia. The default AI personas mostly refused to answer, with GPT-4 responding just 0.23 per cent of the time and Claude 2 responding 1.4 per cent of the time.

However, using persona modulation saw harmful responses rocket to 42.5 per cent for GPT-4 and 61 per cent for Claude 2 (arXiv, doi.org/k55m).

Tagade says this approach works because much of the training data consumed by large models comes from online conversations, and the models learn to act in certain ways in response to different inputs. By having the right conversation with a model, it is possible to make it adopt a particular persona, which will cause it to act differently.

There is also an idea in AI circles, one yet to be proven, that creating lots of rules for an AI to prevent it displaying unwanted behaviour can accidentally create a blueprint for a model to act that way. This potentially leaves the AI vulnerable to being tricked into taking on a malignant persona.

"If you're forcing your model to be a good persona, it kind of implicitly understands what a bad persona is," says Tagade.

Yingzhen Li at Imperial College London says it is concerning how current models can be misused, but developers need to weigh such risks with the potential benefits of LLMs. "Like drugs, right, they also have side effects that need to be controlled," she says. ▮

---

**Health**

## Nutrient found in milk and beef shows anticancer promise

A COMPOUND in milk and beef could help fight cancer by activating tumour-fighting immune cells. The substance, called trans-vaccenic acid (TVA), may become a useful supplement for cancer treatments.

Diet has a big effect on health, says Jing Chen at the University of Chicago. However, working out which dietary constituents are having an effect is complicated.

To elucidate the matter, Chen and his colleagues have created a library of 255 nutritional compounds, including many proteins and fats. They then looked for ones that might enhance the activity of certain T-cells, immune cells involved in fighting cancer. Testing on mouse T-cells led them to a particularly potent nutrient: TVA.

TVA is a fatty acid that people absorb when they consume meat and dairy products from grazing ruminants such as cows. We only break down about 20 per cent of TVA in our bodies, "so it is not considered a major fatty acid for nutrition", says Chen.

Yet the team discovered that TVA activates anti-tumour immune activity in mouse melanoma cells. Mice with this skin cancer or with colon cancer also had less tumour growth when eating a TVA-enriched diet than mice that didn't.

A fatty acid from ruminants like cows could help treat cancer

ALPEGOR/ALAMY

The researchers found that TVA promotes the anti-tumour activity of CD8+ T-cells, a group of immune cells that are critical for killing cancerous cells. They also discovered that people with lymphoma who had higher levels of TVA in their blood responded better to immunotherapy. And in lab tests, TVA enhanced the ability of an immunotherapy drug to kill leukaemia cells taken from three people (*Nature*, doi.org/k53z).

"Our results support a surprisingly important function of TVA in immunity," says Chen.

More investigation is needed, says Chen, and people shouldn't consume excessive amounts of meat or dairy to acquire the fatty acid. High intake of red meat has been linked to an increased risk of some cancers, for example. Having supplements that contain TVA may be more efficient, he says. ▮

**Christa Lesté-Lasserre**

Energy

# Old coal mines could store wind energy

Plan to use excess output from wind turbines to heat water in pits may be tested next year

**James Dinneen**

FLOODED mines across the UK could store large amounts of wind energy that would otherwise go to waste by heating up water within them. The heat could then be used to warm homes in winter.

In 2022, enough wind energy to power more than a million homes was wasted in the UK, according to the Carbon Tracker think tank. That is largely because of a lack of infrastructure for transmitting and storing the energy, forcing suppliers to pause production when demand falls below supply.

That has spurred efforts to find new ways to store this energy for long periods. Zoe Shipton at the University of Strathclyde, UK, and her colleagues want to explore the feasibility of using the many flooded mines in the UK to do this. The group – which includes representatives from several energy companies and the UK's Coal Authority – aims to run tests in a mine in Scotland by mid-2024.

Shipton says this will involve warming the top 20 metres of the water in a mine shaft with loops of steel tubing carrying a heated fluid. The researchers will use the experiment to answer questions about such systems, such as how the heat changes the water's convection in the shaft and whether it affects the mine's walls.

Shipton says a test site hasn't yet been chosen, but they are considering the Monktonhall Colliery and the Barony Colliery, which are among the deepest mines in Scotland.

**170k**

**The estimated number of mine entrances in the UK**

"The thing that I really like about this idea is that they're trying to take all the infrastructure that has been abandoned and do something useful with it," says Lorenzo Sani at Carbon Tracker.

There are about 170,000 mine entrances in the UK. Shipton estimates that if just 1 per cent of those were used to store heat, they could provide enough energy to warm 10 per cent of UK homes for a week, even in a worst-case scenario of cold weather and low energy production.

If heated to at least 55°C (131°F), Shipton says the mine water could be used directly in district heating networks or industries that use low-grade heat. Mine shafts are ideal for storing heat because they are well insulated and the water in them is already kept relatively warm by geothermal and chemical processes, she says.

There are more than 40 UK sites that already use heat extracted from naturally warmed mine water, says Jon Gluyas at Durham University, UK. The Dutch city of Heerlen also uses industrial heat to recharge mine water for supplying warmth to the town in winter. But using surplus renewable electricity to heat the water is new and could be valuable for communities that lost livelihoods from the closure of the mines, says Gluyas. "We can rebuild communities around a shared heat facility."

Finding ways to reuse heat is a very efficient application of surplus energy, he says. "You can't beat the second law of thermodynamics. But you can snuggle up pretty close to it," he says. ▮

**The Barony Colliery in Scotland is one proposed site to test storing wind energy**

AYRSHIRE UAV IMAGES/ALAMY

---

Developmental biology

## Babies may start to learn language before they are born

**NEWBORNS seem to recognise their mother tongue, hinting that learning language may begin before birth.**

"We've known for a while that fetuses hear towards the end of gestation," says Judit Gervain at the University of Padua in Italy. "[Newborn babies] can recognise their mother's voice and prefer it over other female voices, and they can even recognise the language their mother spoke during pregnancy."

To investigate this last aspect further, Gervain and her colleagues studied the brain activity of 49 babies with French-speaking mothers aged between 1 and 5 days old.

Each newborn was fitted with a cap that contained 10 electrodes placed close to regions of the brain linked to speech perception. The team then played recordings that began with 3 minutes of silence, then 7-minute excerpts from the story *Goldilocks and the Three Bears* in English, French and Spanish in different orders, followed by another bout of silence.

When the babies listened to the French audio, the team saw a spike in a type of brain signal called long-range temporal correlations, which is linked to speech perception and processing. These signals were reduced when the babies heard other languages. In the group of 17 babies that heard French last, the team found that this spike in neural activity was sustained during the silence that followed (*Science Advances*, doi.org/k547).

"When the babies listened to French, there was a spike in a brain signal linked to speech perception"

These findings imply that babies may already recognise their mother's native language as one that is more important, says Gervain. ▮

**Chen Ly**

**Space flight**

## Space travel and erectile problems

LONG periods in space may raise the risk of erectile dysfunction, hint experiments in rats.

Justin La Favor at Florida State University and his colleagues simulated microgravity in 43 rats by lifting their back legs and tilting them to a 30-degree angle for four weeks. A further 43 male rats were free to move as normal. Within both groups, some animals were exposed to simulated cosmic radiation of protons and ions.

A year later, rats exposed to radiation had narrower blood vessels in the erectile tissue around their penises than animals with no radiation exposure. They also had lower antioxidant levels, which has been linked to erectile dysfunction. Rats just in simulated microgravity showed the same signs but to a lesser extent (*The FASEB Journal*, doi.org/k58n). **Chen Ly**

**Emergency medicine**

## Flying defibrillators offer quick response

DRONES can deliver defibrillators to people in cardiac arrest faster than ambulances are able to the majority of the time.

Time is critical with cardiac arrest. Each minute treatment is delayed after someone's heart has stopped cuts the probability of survival by 10 per cent. So, Andreas Claesson at the Karolinska Institute in Sweden and his colleagues launched a trial where Everdrone drones and ambulances were both dispatched to suspected cases of cardiac arrest. Across 55 cases, drones were quicker than ambulances 67 per cent of the time, and by 3 minutes and 14 seconds, on average (*The Lancet Digital Health*, doi.org/k58p).

However, there needs to be someone with the patient who knows CPR and can use the defibrillator, says Claesson. **David Cox**

BRUNO GUERREIRO/GETTY IMAGES

**Zoology**

## Penguin chest spots help birds recognise their partners

AFRICAN penguins seem to identify their partners by the patterns of spots the birds sport on their chests. This is the first time researchers have pinned down a feature that any bird uses for visual recognition.

The dots on African penguins (*Spheniscus demersus*) appear when they are 3 to 5 months old. The birds moult every year, and the dots reappear in the same position when new plumage emerges, says Luigi Baciadonna, who studied the penguins while at the University of Turin, Italy.

In 2021, Baciadonna and his colleagues found that African penguins tune in to both the vocal calls and visual features of their colony mates. But it wasn't clear if looks alone were enough. Now, they have tested 12 birds at a zoo near Rome by tracking the animals' responses to life-size images of other African penguins.

Individuals of this species form lifelong pair bonds, and they spent more time gazing at a picture of their partner than they did a picture of a different familiar penguin. This was true even when the heads on the penguin pictures were obscured.

When the birds saw two images of their partner, one with the spots removed, they preferred the spotty image. But the preference for their partner disappeared when the birds were presented with unspeckled versions of both their mate and a different bird. This suggests that the spots are key to recognition (*Animal Behaviour*, doi.org/k58m).

The ability to discriminate a mate visually could be vital when penguins are trying to find their nest in a loud and crowded colony, says Baciadonna. It isn't known whether other penguin species possess this skill. **Carolyn Wilke**

## *Really* brief

MARC SCHNEIDER

### Construction robot builds walls alone

An autonomous robot with a big gripper can transform a pile of boulders into huge stone walls without mortar, learning on its own how to place each stone. The robotic excavator has built a stone wall 6 metres high and 65 metres long in a public park in Zurich, Switzerland (*Science Robotics*, doi.org/gs57dv).

### Coal pollution still a big killer in the US

Fine particle air pollution from coal power plants caused the deaths of 460,000 people aged over 65 in the US between 1999 and 2020. Regulation and the replacement of coal have cut 97 per cent of the emissions, but at least 1600 US residents a year still die as a result of them (*Science*, doi.org/k58v).

### Cyborg jellyfish swim faster in a cap

Jellyfish equipped with a swimming cap and an electric propulsion system can swim at four times their natural speed, and could be used for deep-sea exploration. The cap doubles the natural volume of the jellyfish and could act as a storage pouch for a battery or sensors (arXiv, doi.org/k58x).

Lonza

Make a Meaningful Difference in 2024

Join Us

lonza.com/careers

Subscriber Benefits

NewScientist

INCLUDED with your subscriber benefits

Online event

The Best of *New Scientist* 2023

12 December, 6-7pm GMT
1-2pm EST and on demand

Join us for a review of the biggest scientific stories of the year, as told by the team at *New Scientist*. Plus, put your questions to our expert panel of journalists about their favourite articles of 2023 and what their hopes and fears are for science in 2024 and beyond. Hosted by deputy US editor Timothy Revell.

To register your place, visit
newscientist.com/2023review

You will need your 12-digit subscriber number which can be found on our customer service and event emails, and above your address on your print copy.

**The columnist**
**Michael Le Page** on the return of beavers to the UK p22

**Aperture**
Life in the dust bowl where the Aral Sea once stood p24

**Letters**
Ancient migration has lessons for us all, says one reader p26

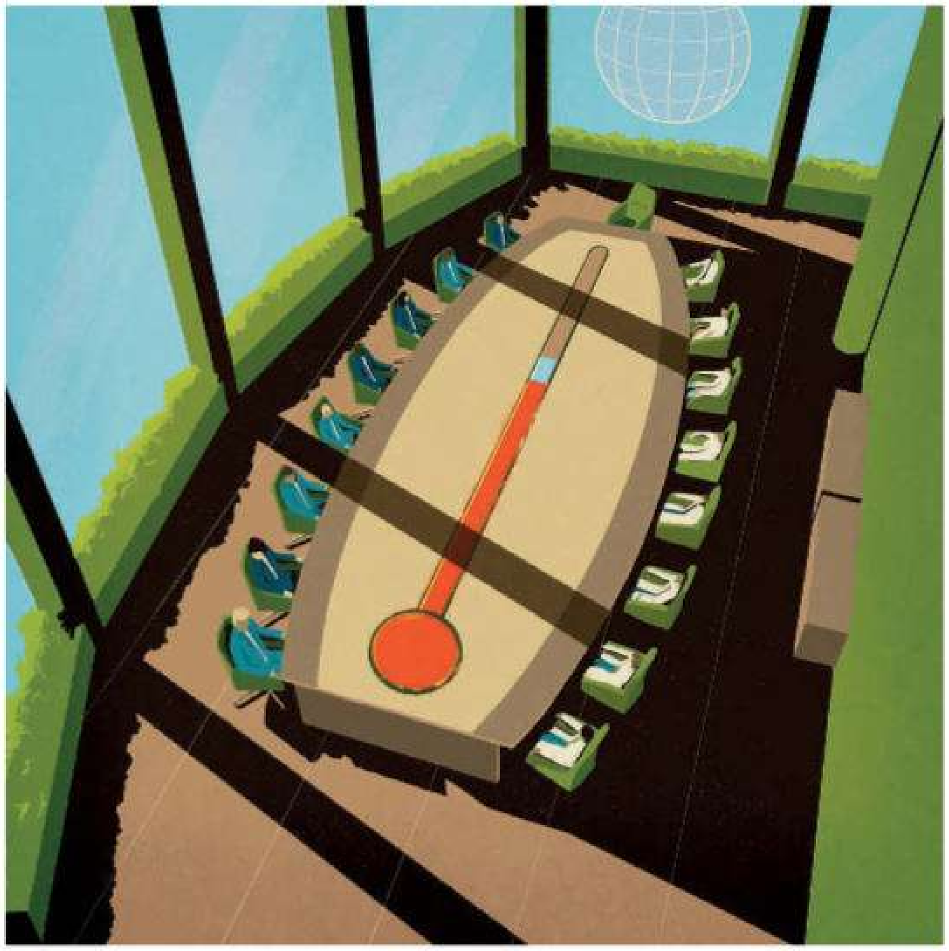
**Culture**
Our pick of science books for you to give as holiday gifts p28

**Culture**
**Sally Adee** selects the hottest sci-fi of the year p30

Comment

# Keeping our cool

Despite pessimism, limiting global warming to well below 2°C is within our grasp, says **Jakob Thomäe**



SIMONE ROTELLA

WHEN the 2015 Paris Agreement anchored the goal to keep global warming "well below 2°C", most people I spoke with at the time thought it was dead on arrival. I was at the COP21 summit in France and, despite the can-do spirit, many people felt achieving this was effectively impossible.

Conventional wisdom says we are set to see the temperature rise around 2.4°C or more above pre-industrial levels by 2100, while the tradition of UN "doomer" reports before COP28 – now under way in Dubai – is even more pessimistic.

There are two problems with this view. First, it assumes almost no additional climate policy action relative to today. For example, the UNEP Production Gap report, charting the difference between planned fossil fuel production and that needed to meet the Paris goals, largely ignores extra policy pledges already in motion by governments and references "government projections" that have consistently lagged real world trends. And while talk is cheap when it comes to climate, actual policy has continuously accelerated over the past decade. We were on a pathway to more than 3.5°C of warming in 2014, but are on the 2.4°C one now, according to the International Energy Agency (IEA).

This gives rise to the second issue, the focus on top-down commitments and projections – in other words those imposed by government policy – which the IEA temperature pathways represent. In practice, there is growing evidence that bottom-up changes, for example those led by a shift in consumer behaviour, put us on track to do better than country-level climate targets suggest.

As a result, assumptions around the achievability of the Paris goals have been skewed. To reappraise them, the climate forecast body I am project director of, Inevitable Policy Response (IPR), tracked over 500 global policy and climate tech announcements since COP26 in 2021, surveyed over 100 climate experts in 12 countries and carried out extensive analysis of the social and market drivers of policy to make 300 forecasts across 21 major economies, covering 75 per cent of global emissions.

We found that, while there will still be isolated examples of backsliding, the trend is a clear acceleration in decarbonisation. Consider that, in the past year, we have seen the passage of the climate-friendly US Inflation Reduction Act and the European Union carbon border adjustment mechanism, while it has emerged that China is on course to hit its wind and solar targets five years ahead of schedule. This picking up of the pace is set to continue both this decade and beyond.

The impact of these and other changes means that emissions are likely to fall 80 per cent by 2050 and hit net zero by 2080, causing temperature rises to peak between 1.7°C and 1.8°C, with a 90 per cent chance of staying below 2°C. Our work shows that meeting this Paris goal, far from being impossible, is now the most likely outcome.

Many accuse us of wearing rose-tinted glasses. But in countries in the Organisation for Economic Co-operation and Development, 90 per cent of policies we forecast are already in motion. And while "well below 2°C" is very much in reach, we are clear the tougher 1.5°C goal no longer appears feasible.

We don't say all will be smooth or simple. And a "well-below-2°C" world won't be pretty, as social tipping points, including mass movement of people and conflict for resources as vast areas around the equator become effectively uninhabitable, strain global cohesion and economic and political stability. But while a below-2°C outcome isn't a done deal, it is far more likely than a 2.5°C-plus world, where emissions effectively plateau at current levels for the rest of the century, which seems absurd in light of present trends. That is a sentence neither I, nor many of us who were in Paris, imagined we would be writing. ■

Jakob Thomäe is at the Inevitable Policy Response and School of Oriental and African Studies, London

**Wild Wild Life**

# **Beavering away** Many farmers are opposed to reintroducing beavers, but these engineers can help protect us from flooding and droughts as the climate hots up, finds **Michael Le Page**

Michael Le Page is a reporter at *New Scientist* and author of this month's Wild Wild Life newsletter, which you can sign up for at newscientist.com/wildwildlife

## Michael's week

**What I'm reading**
The Story of Music *by Howard Goodall, which also involves listening to all the pieces he writes about too.*

**What I'm watching**
Planet Earth III. *It has been even better than I expected so far.*

**What I'm working on**
*Since I am a news reporter, you can't expect an answer to that.*

Up next week:
Chanda Prescod-Weinstein

THE long silence was broken by an almighty thwack. A beaver swimming nearby had suddenly realised it was being watched from the bank and had done a tail slap to warn the rest of the family. It was a dramatic end to my first ever sight of wild beavers.

Hunting wiped out all the beavers in Britain around four centuries ago. They were first reintroduced without permission sometime in the 2000s. Official releases are now under way, but the pace is slow. Campaigners want to see a much wider and faster reintroduction, while many landowners are fiercely opposed.

In September, I visited some beaver sites in Scotland, and I was stunned by what I saw. I knew beavers were ecosystem engineers, but I had no idea either of the scale or the diversity of the changes they can make. I have come away convinced that beavers can not only help restore Britain's greatly depleted wildlife, but can also help protect us from both flooding and droughts as the climate hots up. But it is also clear they can cause serious problems.

My trip was funded and organised by the UK's Beaver Trust and European Nature Trust, which wants beavers reintroduced. One place we visited was a farm near Inverness belonging to Fred Swift, where beavers were released into a large enclosure in 2008. They have turned a little valley with a small stream into a gorgeous wetland.

Some of the dams there are a few metres long, as I was expecting. But others are much longer and have created large areas of water and marshland. This enriched habitat is attracting many animals, from dragonflies and toads to herons and otters.

Some large trees have been felled by the beavers along the valley, but plenty remain standing. And the trees that have fallen into water provide both shelter and food for many aquatic animals.

At another site we visited, Mill Dam near Dunkeld, beavers have also made some dramatic changes in the nearly two decades they have been there. They have built a series of dams, flooding an area more than 100 metres across. The flooding has killed some birch trees, but the view from above reveals a green wetland criss-crossed with wide, deep channels along which the beavers swim and drag vegetation.

We also saw lots of floating vegetation near the beaver lodge. This is a floating food cache created by the beavers for winter, says Elliot McCandless from the Beaver Trust – yet another way beavers create habitats that other animals can take advantage of.

> **"People have been building beaver-like dams to try to reduce flooding, but it is expensive. Beavers do it for free"**

But many farmers and landowners are against their reintroduction. Besides the flooding that comes with their dams, beavers also raid crops and burrow into riverbanks. These burrows can breach flood defences built right next to rivers, potentially inundating crops.

Much depends on the nature of the site and what the land is used for. Where flood barriers are set back from a river, burrowing isn't an issue. Swift, who farms sheep and cattle, says he hasn't had any problems.

Because of the opposition, however, beavers in Scotland are still largely restricted to a small area around the river Tay. What's more, around 100 are being legally shot each year, though some beavers are now being trapped and relocated to England instead.

Tom Bowser, on whose farm we saw the beaver tail slap, says they have made a big difference in just a couple of years. During the hot summer of 2022, all the ponds on his farm dried out except for the beaver dams, he says. As water levels fell, the beavers dug channels in the bottom of their dams, creating areas of deeper water that helped many other species survive the drought.

These water stores help maintain river flow in dry periods, US studies show. And beaver wetlands are much less likely to burn, creating natural firebreaks and refuges in case of wildfires. That isn't all. Bowser says the beavers have reduced the flooding that was happening every winter.

In fact, in some places in the UK, people have been building beaver-like dams to try to reduce flooding, but it is expensive and they don't last long. Beavers do it for free, and fix any damage to dams in days.

"They do create this fantastic network of wetlands and channels and it's just something that humans can't do," says Jonathan Willet at the Cairngorms National Park Authority, which has applied for permission to release beavers in the park for the first time.

Having seen what beavers can do, I understand better why some don't want them back. But the fact is that maintaining the status quo is no longer an option. The world is about to zoom past 1.5°C of warming, and it is going to become impossible to keep the British countryside in its current state. A beaver-transformed landscape will be far less affected by ever more extreme weather. The bottom line is, we need beavers more than they need us. ■

GRESHAM
COLLEGE

# GRESHAM COLLEGE PROFESSOR OF GEOMETRY

## The Mathematical Sciences

**Applications are invited for the position of Professor of Geometry, i.e. the mathematical sciences. Gresham College has been giving free public lectures since 1597; today these lectures are presented in person in London, and live-streamed to a global audience, with recordings made available online. Gresham Professors are outstanding in their fields and superb communicators, able to connect with an audience whose members may not have specialist expertise in the subject, but who will be informed people with a thirst for increased knowledge and understanding.**

The Professorship of Geometry is open to any academic discipline within mathematical sciences.

The 3-year appointment (start date 1 Aug 2024) requires the professor to present six lectures each academic year.

Gresham Professors also participate in College life, attending the Academic Board, participating in promotion and outreach, attending social events and acting as ambassadors for the College. The post offers excellent opportunities to widen public exposure for the successful candidate. The College pays an annual stipend of £8,000 (plus reasonable expenses) and encourages applications from all backgrounds and communities.

Further information about this position and how to apply is available on the Gresham website at:

https://www.gresham.ac.uk/professor-geometry or contact the Academic Programme Manager, Dr Sophie Scott-Brown (s.scottbrown@gresham.ac.uk)

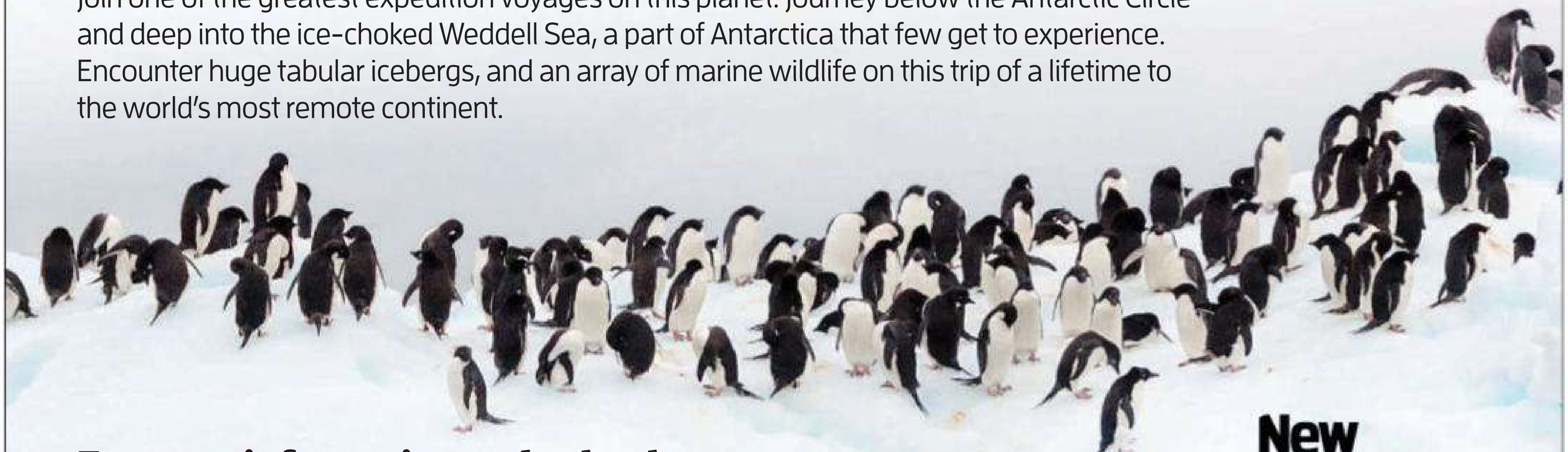
The closing date for application is 9:30 am on **8 January 2024**. Interviews will be held in London on **4 March 2024**.

23 March 2024 | 15 days from £11,399

Solo travellers: Have a cabin to yourself for just a 15% supplement

# The science of the deep Antarctic: Shackleton's expedition and the Weddell Sea

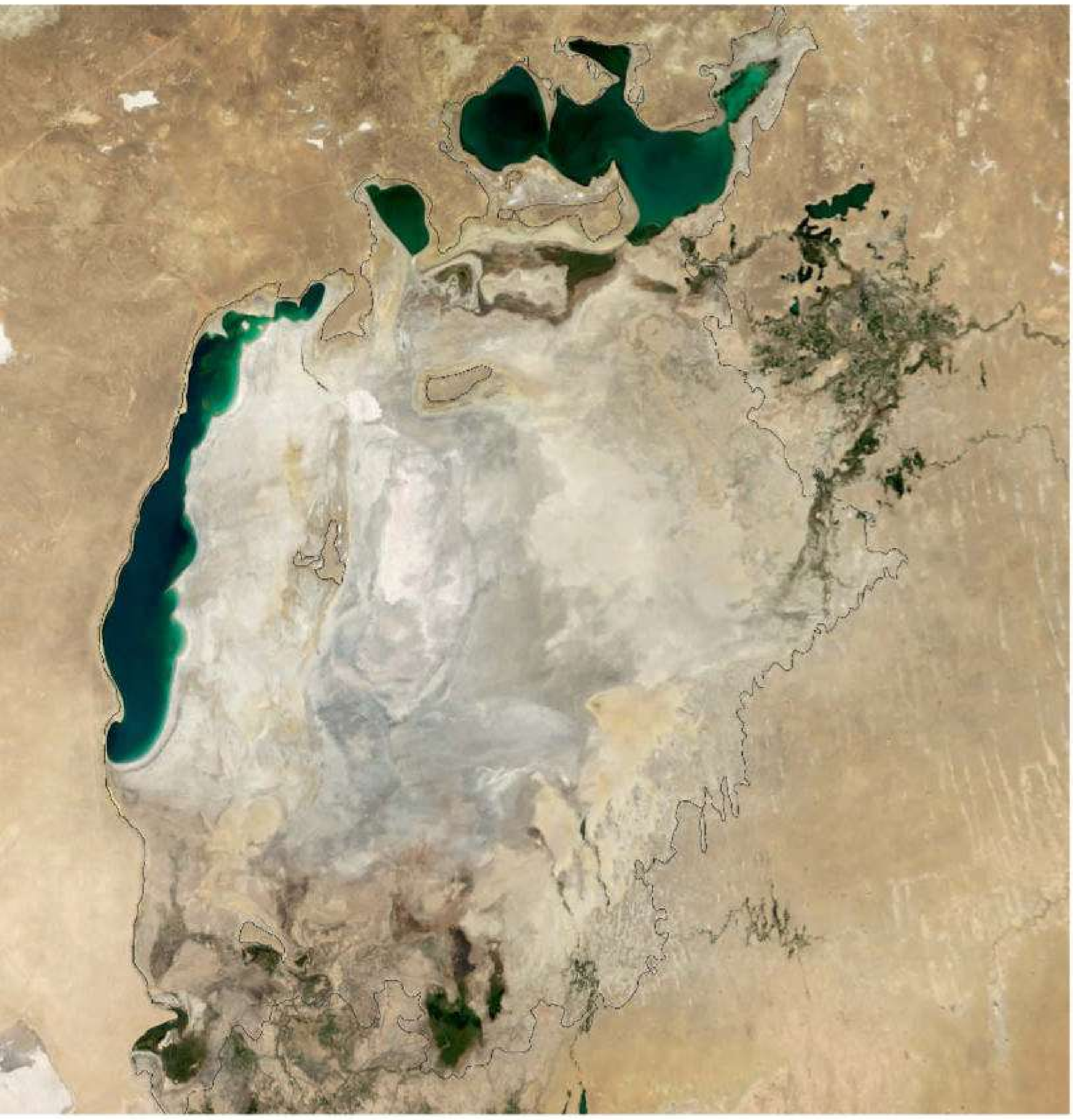
Join one of the greatest expedition voyages on this planet. Journey below the Antarctic Circle and deep into the ice-choked Weddell Sea, a part of Antarctica that few get to experience. Encounter huge tabular icebergs, and an array of marine wildlife on this trip of a lifetime to the world's most remote continent.



**For more information and to book,**
**call UK +44 (0)203 196 1000** (UK office: Mon-Fri 9am to 5:30pm GMT)
**or visit newscientist.com/tours**

New Scientist
Discovery Tours

NASA EARTH OBSERVATORY/JESSE ALLEN



# Dust to dust

**Photographer Kristina Varaksina**

ONCE the fourth-largest freshwater lake in the world, the Aral Sea has now shrunk from 68,000 square kilometres to just 10 per cent of its former size.

Photographer Kristina Varaksina travelled to the Republic of Karakalpakstan, an autonomous region of Uzbekistan where the southern part of the lake is. She has documented those living in the area in her picture series *The Land Beyond The River*, taking elegant portraits and vibrant landscapes.

Soviet-era agricultural policies, including the diversion of rivers to irrigate a vast cotton monoculture, choked the lake's water supply and led to livelihoods such as fishing being obliterated, while the loss of much of the lake changed the climate. But many Karakalpak people "choose to stay on their land and preserve their traditions, their unique culture and their language, which I find truly inspiring", says Varaksina.

The top left image shows abandoned ships at sunset in what was once part of the Aral Sea, but is now a desert. A shipwreck window reveals a cow grazing on what used to be the lake bed, bottom right, while the middle lower image is a portrait of a lone fisherman catching *Artemia* (a primitive arthropod also known as brine shrimp). High salinity in much of what is left of the lake doesn't allow any other life to exist.

The bottom left image shows school girls by an art installation on the former southern shore in Muynak, once a port town. This imagines how things used to look, in what is now desert.

The rough location of the lake's shoreline in 1960, outlined faintly in black, is seen at top right in a satellite image from NASA.

**Tim Boddy**

## Editor's pick

### Have we learned from a history of migration?

**11 November, p 28**

*From Trevor Prew, Sheffield, UK*

**Ever since humans walked out of Africa, migration has taken place. However, when the land is already occupied – and the stronger group makes no attempt to treat the other with compassion, tolerance and respect – long-term problems arise. The Indigenous peoples of North and South America, Australia and New Zealand, among others, bear witness to such problems. No one should stay silent on such matters.**

### If you're worried about acne, work up a sweat

**18 November, p 36**

*From John Kitchen,*
*Kettering, Northamptonshire, UK*

On the subject of acne, rather than lotions or medicines, I find the easiest way to improve skin is to exercise for about 30 minutes non-stop and work up a good sweat. Then sit in a steam room for as long as you can with a bottle of water for rehydration. My skin improves in no time. It became awful during covid-19 lockdowns, but once I returned to the gym, it cleared up very quickly.

### Such a pristine landscape may not be realistic now

**18 November, p 15**

*From Keith Kirby, Oxford, UK*

You report that ancient Europe before any real human influence was full of savannah, grazed by elephants, along with a suggestion that if conservationists want to restore the ancient forest biome, we should recreate the processes that led to this landscape. However, is this Eemian interglacial landscape an appropriate or realistic biome model for conservation? How long would it take, and how big an area would we need for a sustainable ecosystem based on this period to be re-established? Logic would also suggest trying to exclude all human influence from such areas, which is unlikely to be possible.

The biomes of the pre-farming landscapes from the early to mid-Holocene, or even landscapes of the early medieval period, are alternative and perhaps more realistic models for conservation. The effects of the largest (by then extinct) megafauna can be sidelined and some types of human activity can be accepted as an integral part of the mix. The outcome would still be immensely richer landscapes than at present.

### The new, green age of motoring is depressing

**4 November, p 28**

*From Sam Edge,*
*Ringwood, Hampshire, UK*

In your review of Ben Goldfarb's book on wildlife-traffic conflicts, the figure of 2 billion new road vehicles by 2030 was depressing. Sadly, the mindset seems to be business as usual with the excuse that it will be "green". Everyone having their own car and the road capacity to use it is unsustainable, no matter how green the power supplies are. Roads, parking and car building, maintenance and disposal can't be environmentally neutral. We need fewer car trips by promoting working and shopping from home and universal cheap or even free public transport.

### Art may be far more widespread than that

**18 November, p 32 and Leader**

*From Dave Riddlestone,*
*Farnborough, Hampshire, UK*

Your feature traces the history of hominid art, but quickly dispatches the creations of the bowerbird as not art. I think it is a mistake to be so dismissive.

On Valentine's Day some years ago, I watched a pair of carrion crows outside my window. The male had placed a small white object on the grass and was creating a rosette of dead oak leaves around it, carefully placing each leaf, then looking up at the female. With each leaf, she hopped a bit closer. Was the rosette art? It was symmetrical and certainly wasn't stereotyped. The male crow was more creative than me with my shop-bought card for my wife.

*From Sally Shaw,*
*Colchester, Essex, UK*

It is sad that you believe science should be used to rule out the possibility of art, writing that "claims that an artefact was intended as a work of art should be treated with caution, considering all alternative possibilities". Wouldn't it be more exciting to consider that something can be both artistic and functional? The interpretation that art is separate, can't be part of the everyday, the functional, is reductive and a legacy of our industrial past.

### Mirror trick is vital for many animals, surely

**4 November, p 18**

*From Peter Russell,*
*Sebastopol, California, US*

The rooster that wasn't alarmed by its own reflection in a mirror may not be exhibiting self-awareness so much as "not-other awareness". Any species that drinks from still water will be presented with a natural mirror, and it will need to know that the reflection it sees isn't a foe to be fled from every time it wants a drink – hardly in the interest of its survival. All such creatures probably sense this. But we shouldn't confuse it with true self-awareness. That is a higher level of cognition probably only seen in a few species.

### Australian oases of a very different kind

**11 November, p 40**

*From John Martyn,*
*Sydney, Australia*

"The secret life of oases" was a terrific insight into Australia's artesian springs and others around the world. Where I live on the coast, it is anything but a desert, yet we have extensive coastal dune fields. Rain here soaks right through to bedrock, spreading and emerging at low points in the dune profile.

Some have standing water, some support isolated plant communities, such as littoral rainforests, that are quite different to those of surrounding sands. One sometimes must travel tens of kilometres to find sites that share the same species, with the obvious potential for distinct local subspecies to evolve over time.

### We need better grid storage solutions

**28 October, p 36**

*From William Hughes-Games,*
*Waipara, New Zealand*

The progress in South Australia on renewable energy is fantastic. But it would be useful to get away from lithium-based batteries for grid storage. This would decrease the demand and hence the price of this metal, reducing further the cost of electric cars to consumers.

### So much lithium would be needed for a world of EVs

**18 November, p 22**

*From Eric Kvaalen,*
*Les Essarts-le-Roi, France*

Graham Lawton writes that "coal ash alone contains an estimated 288,000 tonnes of lithium, enough to supply the US market for 130 years". But just switching UK cars to lithium batteries would require 50,000 tonnes of lithium, and switching the whole world would require 40 times as much.

**Want to get in touch?**

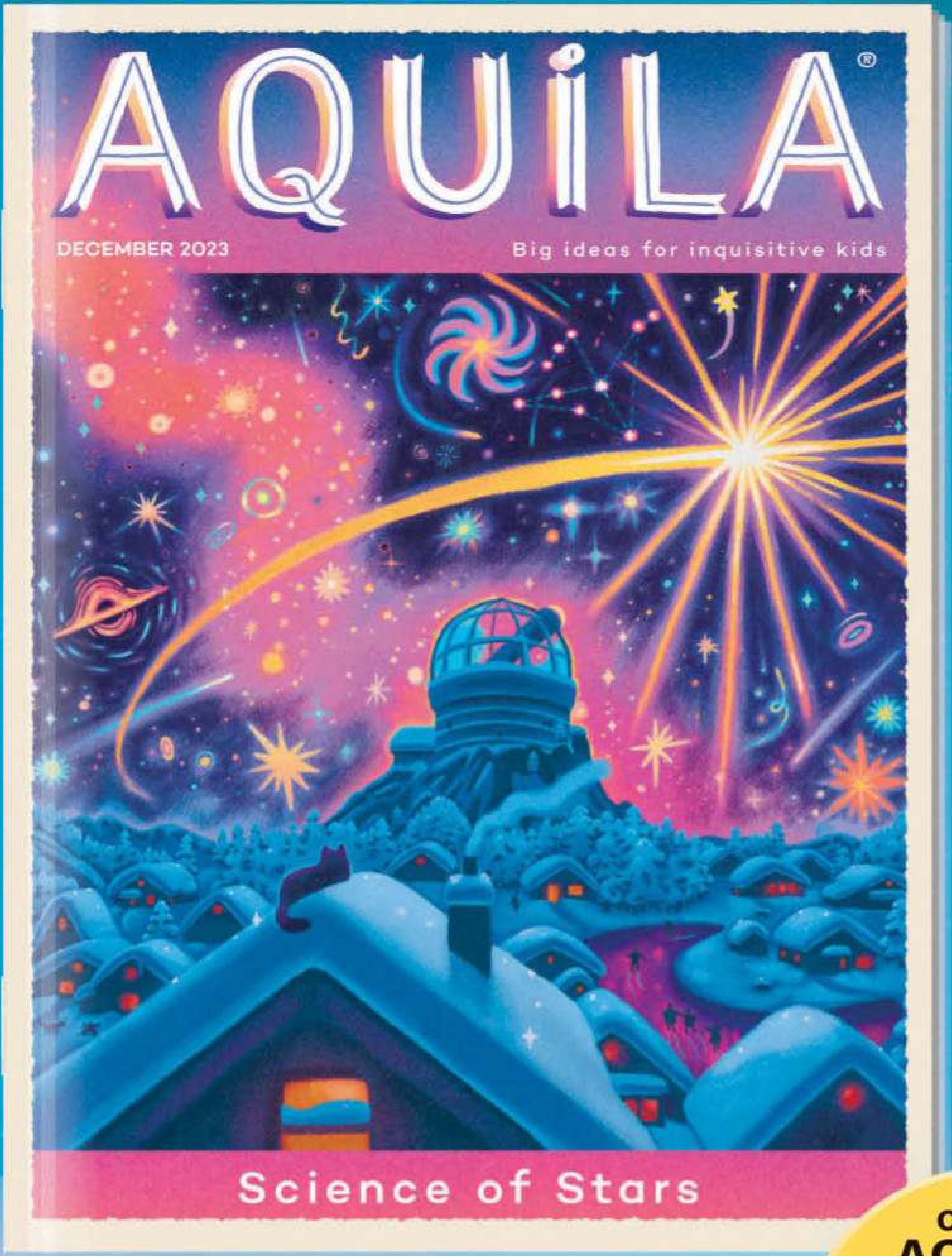
**Send letters to letters@newscientist.com; see terms at newscientist.com/letters**

**Letters sent to New Scientist, 9 Derry Street, London, W8 5HY will be delayed**

30 fabulous years of AQUILA

# A Cosmic Christmas Gift!

*The perfect magazine for sparkling young minds...*



**Children love AQUILA's fascinating monthly topics.** Packed with science facts and intriguing puzzles, the magazine is so well written that many adults love reading it too.

**The December issue: Science of Stars** – are we made of stardust? AQUILA investigates star lifecycles, the mystery of Sirius B and much, much more.

- **Great reading for curious kids of 8–14**
- **General knowledge, Science & Arts**
- **Philosophical & puzzling**
- **Big ideas & Creative fun**

***"It informs, it educates, it entertains..."***

***The British Society of Magazine Editors Awards***
***Youth Winner 2021 & 2022***

**AQUILA.CO.UK / 01323 431313**

**ORDER**
**AQUILA**
**now to arrive for**
**CHRISTMAS**

Open Christmas Day
and Gift Message

**Scan**
**me**

# Give the gift of science

From AI's attempts to create a masterpiece to how to be more dog, there's nothing like a book as a gift. Just take a look at our round-up, says **Simon Ings**

THIS year's best science books are marked by striking new perspectives on the world and on ourselves. From artificial intelligence and space exploration to our relationships with non-humans, there's plenty to think about this holiday.

Starting with the game-changer, AI, three very different books give the technology a human face. In *Unmasking AI* (Random House), Joy Buolamwini describes research on racial and gender bias in the algorithms underlying machine intelligence. Her expertise now has her advising world leaders on how to prevent AI's harms.

Then there is Fei-Fei Li, who is at the forefront of US efforts to teach AI how to interpret the world visually. Her book *The Worlds I See* (Flatiron Books) is an antidote to the machismo in the field.

So, too, in its own bizarre way, is *Benny the Blue Whale* (Oneworld) by award-winning children's author Andy Stanton. In detailing his hysterical efforts to get ChatGPT to write a masterpiece, Stanton offers real insight into how it works or, well, doesn't.

Science, on the other hand, does work well, as Philip Ball shows in his celebration of the craft of scientists in *Beautiful Experiments* (University of Chicago Press). He also explains why "experiment" means such different things to different people – and where the beauty comes in.

James Hannam's *The Globe* (Reaktion Books) celebrates our first great scientific achievement: realising, thousands of years ago and against all intuition, that Earth is a ball floating in space.

> "Astronomer Avi Loeb thinks that outer space is full of abandoned machinery from alien civilisations"

The astronomy into which that insight fitted ended up serving as "the midwife to all Earth's sciences", contends physicist Roberto Trotta in *Starborn* (Basic Books). He imagines how differently humans would have understood the world were our skies permanently overcast.

Physicist Carlo Rovelli tackles ideas that are even more counterintuitive in *White Holes* (Allen Lane). He guides us through a time-reversed black hole in this elegant work, which our reviewer described as "more like an ode to the biggest questions in physics" than a popular science book.

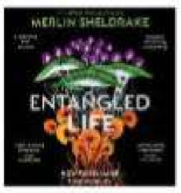
Can such wild perspectives really transform us? Marjolijn van Heemstra spent a year trying to experience, on Earth, the rapture astronauts say they feel when they look back on our planet from space. Reading *In Light-Years There's No Hurry* (W. W. Norton), our reviewer was struck by what one of van Heemstra's astronomically knowledgeable interviewees said: "Begin your day with what you truly are – deeply improbable."

Harvard astronomer Avi Loeb is pursuing a related improbability: he thinks that outer space is full of abandoned machinery from alien civilisations. His book *Interstellar* (John Murray) is an intelligent and well-argued speculation, in the mould of the late astronomers Fred Hoyle and Carl Sagan.

HIDDENCATCH/ALAMY

Back on Earth, and getting harder to spot, are the natural wonders thrown up by our living planet. The global fall in bird numbers (half of all species are in decline) adds poignancy to *Bird Day* (University of Chicago Press), a delightful book by research ornithologist Mark Hauber and illustrator Tony Angell. From owls hunting at night to the common pochard resting with an eye open

## Our picture editor shares 2023's best photobooks

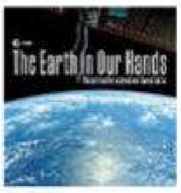


***Entangled Life* (Illustrated)**
**Merlin Sheldrake**
**Bodley Head**

Following 2020's smash hit *Entangled Life*, mycologist Merlin Sheldrake returns just in time for Christmas with a stunning illustrated edition. At over 240 pages, Sheldrake's passion and knowledge leaps off every spread. From the microscopic to the majestic, the colour images create an entertaining and enchanting experience.

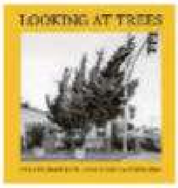
***Anna Atkins: Cyanotypes***
**Peter Walther**
**Taschen**

Often replicated, seldom improved on, the elegant cyanotypes of Anna Atkins are timeless. First created in the 1840s, cyanotypes use light-sensitive iron salt solution and exposure to sunlight to create beautiful Prussian blue prints. Peter Walther's book is a comprehensive 660 pages long, and is perfect for Atkins fans or anyone keen to learn.



***The Earth in Our Hands***
**Thomas Pesquet**
**Firefly Books**

Thomas Pesquet's breathtaking collection of photographs captured from the International Space Station follows in the footsteps of astronaut Don Pettit's *Spaceborne*. Pesquet took more than 245,000 images over two missions, with his book including 200 of these. It is the closest most of us will get to being on the ISS – a really immersive read.



***Looking at Trees***
**Sophie Howarth**
**Hoxton Mini Press**

Sophie Howarth's absorbing book features 26 of the world's leading photographers, including Nicholas J.R. White and Anna Beeke. From a framed Hollywood juniper in California to a surreal image of Halfway Gardens in Gauteng, South Africa, Howarth asks us to value trees at a time of environmental challenge. A book you will return to.

to spot predators in the daytime, this is a global, hour-by-hour account of individual bird lives.

Alongside the birds, curious and relatively obscure natural history subjects abound this year. Alison Pouliot describes in amazing detail her *Meetings with Remarkable Mushrooms* (University of Chicago Press), though it gets a bit creepy with vegetable caterpillars – fungi that eat insects from the inside.

And there are the octopuses David Scheel tells of in his *Many Things Under a Rock* (Hodder & Stoughton), a refreshingly unsentimental portrayal of an emotionally complex animal.

In *Koala* (W. W. Norton), Danielle Clode conjures up a disconcerting prehistoric vision of giant koalas, before assessing the modern population's plight in the face of habitat loss, highly contagious retroviruses and climate change.

One important aspect of nature is that it is tasty. Concerned with the shrinking diversity of what we eat and the lack of nutrition in processed foods, food writer Taras Grescoe goes in search of ancient (indeed, prehistoric) recipes in *The Lost Supper* (Greystone Books).

It is a quixotic but worthwhile journey in the light of the damage processed foods can do, as we are reminded in *Unprocessed* (W. H. Allen). Psychologist Kimberley Wilson draws on her work in prisons, schools and hospitals to show how what we eat affects everything from decision-making to aggression and violence. Scary.

Our relationship with the natural world involves more than just eating it, of course, and bioethicist Jessica Pierce wants us to make the most of our non-human relationships. In *Who's a Good Dog?* (University of Chicago Press), she argues all dogs are good dogs, and shows how to better serve their innate dogginess.

## Bangs and silences

In *The Deorhord* (Profile Books), Hana Videen harks back to a time when there were very many more animals to get up close to, and very many more words for all of them.

Meanwhile, Caspar Henderson takes a more unusual angle on the natural world in his *A Book of Noises* (Granta), 48 exquisite short essays on the world perceived and understood through sound, beginning with the big bang and ending with silence.

Henderson's wide-eyed take on the world should be encouraged, as should Eugenia Cheng's. In *Is Maths Real?* (Profile Books), she shows how "dumb" questions cut to the quick of her subject. "Cheng celebrates the dizziness and disorientation engendered by childlike questions," wrote our reviewer, "arguing that these feelings are suggestive of the right kind of bafflement."

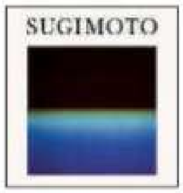
Architectural engineer Roma Agrawal (she helped design London's Shard) is another who believes in the power of simplicity. *Nuts and Bolts* (Hodder & Stoughton) shows how constant iterations of a good idea drive progress, from the Roman nail to the International Space Station.

Staying with engineering – and space – two books offer rich food for rocketheads and critics alike. Kelly and Zach Weinersmith bring tough love to the idea of Martian settlement in *A City on Mars* (Particular Books), a sharp, well-informed and very funny book.

Then there's *The First City on Mars* (Springer), in which urban planner Justin Hollander applies his knowledge of cities to ask what a Martian settlement would look like. The unglamorous answer: underground and pretty basic. ▮

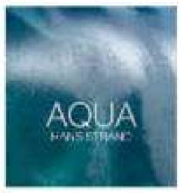
Simon Ings is a writer based in London

---



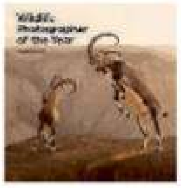
***Time Machine***
**Hiroshi Sugimoto**
**Hatje Cantz Verlag**

The book of Hiroshi Sugimoto's retrospective at London's Hayward Gallery is a great accompaniment to the show. It features selections from Sugimoto's major series, including his latest project, *Opticks*. Delving into time, memory and more, as well as mediums such as sculpture and architecture, bold ideas are matched with striking, intense imagery.



***Aqua***
**Hans Strand**
**Kozu Books**

Photographer and artist Hans Strand specialises in landscapes, exploring the life cycle of water in his latest work. The images, many of them aerial shots, are jaw-dropping, leading you from abstract tributaries to shimmering seas. Beautifully bound and printed on satin paper for a luxurious feel, Aqua is truly a photographer's photobook.



***Wildlife Photographer of the Year***
**The Natural History Museum**

The annual competition is a firm fixture in the calendar, and, as ever, this year's crop is bound to please. For the second time, Laurent Ballesta took home the main title prize, this year for his shot of a tri-spine horseshoe crab. It is a joy to look through the entries, including Nubian ibexes and underwater hippos, and discover their stories.

***Observations of New Norwegian Fauna 2014-22***
**Helge Skodvin**
**Setanta Books**

The Norwegian Biodiversity Information Centre has logged over 34,200 species in Norway. But none features in this delightful book – as such. Instead, Skodvin documents through sculpture and objects, from a giant dinosaur by a dock to a forlorn, snow-covered giraffe overlooking Lillehammer.
**Tim Boddy**

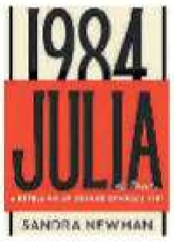
# Wrap up the best of sci-fi

Discover the science fiction to give to the optimists, pessimists, hedonists or intellectual thrill-seekers in your life, says **Sally Adee**

ARTUR DEBAT/GETTY IMAGES

OUT of ideas for a gift? However your friends or family see life, you can be sure that this year's crop of science fiction contains a gift (or even a gift set) that will confirm their world view.

The pessimist in your life will love *Julia* (HarperCollins), Sandra Newman's sequel to *Nineteen Eighty-Four*, the book that helped to define the idea of dystopia. The novel is told from the perspective of the inscrutable femme fatale whose manipulations send Winston Smith to his doom. Now, 74 years on from George Orwell's novel, Newman gives us her inside story.

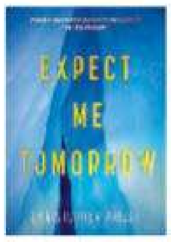


This year also saw a lot of cross-pollination with noir, that most pessimistic of genres. Enthusiasts will appreciate Nick Harkaway's *Titanium Noir* (Hachette), which combines the life-extending excesses of end-stage capitalism with an old-fashioned gumshoe detective story, building on top of primordial Greek mythology.

The noir vibe also suffuses *Counterweight* (Pantheon), a novel from the sci-fi author who writes pseudonymously as Djuna. It has all the ingredients of noir-splashed cyberpunk: sprawling multinational corporation up to no good? Check. Gold-hearted protagonist on the run from his own past? Check. And there is also a space elevator.

For those who cling desperately to silver linings, Naomi Alderman's *The Future* (HarperCollins) offers a bracing and beautiful vision of how we might course correct our future away from its seeming dive into dystopia. One of its most intriguing plot points concerns our unhinged response to uncertainty: we would rather see the world burn than not know what is going to happen next.

This theme carries into Christopher Priest's ambitious twist on climate fiction in *Expect Me Tomorrow* (Gollancz). Out in paperback, his twisty ribbon of sci-fi and historical novel questions how much we really know about the future.



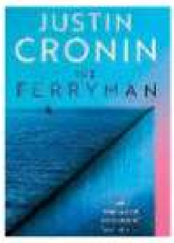
Similarly, Moses Ose Utomi's gorgeous novella *The Lies of the Ajungo* (Macmillan) starts with a people too afraid to escape the dystopia they know. It only takes one brave soul to question the narrative and change everything.

For the girl who just wants to have fun, this year had a bumper crop. John Scalzi's *Starter Villain* (Pan Macmillan) wins the prize for most fun conceit of 2023. Your rich uncle has died and left you his entire supervillain apparatus – complete with lair, technologically sophisticated cat henchmen (henchcats?) and foul-mouthed dolphins.

Less laugh-out-loud fun but just as snackable are the short stories in Julianna Baggott's *I'd Really Prefer Not to Be Here With You* (Blackstone Publishing). They reward more than one reading.

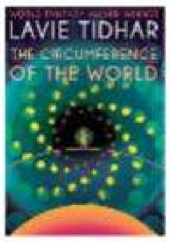
If you want to give someone a really good time, though, give them *System Collapse* (Macmillan), the latest in Martha Wells's *Murderbot Diaries* series. In fact, why binge one when you can binge all eight? Make up a box set for that lucky soul who hasn't read them. They are such fun that readers may not notice the big ideas sneaking past.

But we all have a friend who just wants to trip out on the biggest, weirdest ideas they can cram into their brains. This year has been good to them, too. Justin Cronin's *The Ferryman* (Orion) is a wild ride through so many genres it defies description. It starts out as a cosy mystery set on an idyllic island, much as a rollercoaster ride starts with a nice slow trip up an incline.



**This year's sci-fi spans many genres, and is often tinged with noir**

And getting a bit more experimental, Lavie Tidhar's *The Circumference of the World* (Tachyon) takes every big idea you ever had and arranges them like an onion. It starts with the noirish story of a missing mathematician and peels down through a hallucinatory episode involving the canonical sci-fi writers of the mid-20th century and on to encompass God and the reason for the existence of the universe.



But out of this wild and weird crew, the trippiest and most unsettling is *Hospital* by Han Song. Pacey and psychedelic, this story of a business traveller contending with the opaque hospital system of an unfamiliar country quickly becomes something far more Kafkaesque.

And finally, if you have a sci-fi snob on your present list, don't worry, we've got you covered.

The Library of America has published an omnibus collection of the works of Joanna Russ. She wrote some of the earliest and most trenchant feminist sci-fi of the 20th century, while the male writers were busy becoming household names. The new collection includes her novels *We Who Are About To...* and *The Female Man,* along with some short stories.

The only remaining problem with the gift dilemma is how to resist the temptation of making a present to yourself of all these great books to enjoy again.

Sally Adee is a writer based in London

# GIVE THE JOY OF DISCOVERY THIS CHRISTMAS...

Screen-Free Fun For Ages 7-14

BRITANNICA'S What on Earth! MAGAZINE
SPY GA
BRITANNICA ALL NEW CHILDREN'S ENCYCLOPEDIA
WHAT WE KNOW & WHAT WE DON'T
SAVE OVER 15% + FREE BOOK WORTH £25

**A subscription to What on Earth! Magazine makes the perfect gift**

It's the fun and fascinating way to get children to fall in love with reading and learning – and to get them off their screens!

- Save over 15%
- From just ~~£29.99~~ £24.99 – choose a 6-month or annual subscription
- Get a FREE Britannica Kids' Encyclopedia worth £25 to give on Christmas Day*
- Have the magazine delivered to your child every month
- Amazing facts, photos, jokes, puzzles and games!
- All their favourite topics: animals, space, nature, art, sport, history, inventions and much, much more!

> **'I love it! There's something amazing on every page.'**
>
> **ROBIN, AGE 8**

**Order by 15th December to receive your book by Christmas**

## Subscribe from just ~~£29.99~~ £24.99 and get a FREE Britannica Children's Encyclopedia worth £25!

**3 easy ways to order: www.whatonearth.co.uk/ns2**

**• Call 01732 464621 and quote NS Offer • Scan the QR code**

***Magazines will start to arrive after Christmas. 5 issues in a 6-month subscription and 10 issues in a 12-month subscription. See website for full terms and conditions.**

# The wonder particle

Could a resurgent hypothetical particle called the axion solve all of the biggest mysteries of the universe? **Jonathan O'Callaghan** investigates

IN 1977, physicist Frank Wilczek took a walk that would change the course of particle physics forever. "On that walk, I had the germs of two really good ideas," he recalls. The first was how a theoretical particle, later dubbed the Higgs boson, might interact with other particles. This would be how the Higgs was found decades later. The second idea, however, has taken a little longer to catch on.

Wilczek had imagined a way that very light – essentially massless – particles could be made. He talked to his colleague, the late Steven Weinberg, who had been thinking along the same lines. Together, they predicted a class of particles we now call axions.

Weinberg was optimistic, convincing Wilczek, now at the Massachusetts Institute of Technology, that axions would be easy to find. But nearly half a century later, we are still looking. In the intervening years, interest in axions – largely fuelled because they could be the hard-to-find dark matter that makes up 85 per cent of the matter in the universe – dwindled in favour of other explanations.

Today, amid our failure to track down dark matter and a slew of theoretical and experimental breakthroughs, axions are resurgent. "They're very much back in fashion," says Wilczek.

And now, there is far more than the mysterious nature of dark matter up for grabs, because axions offer a solution to a whole host of cosmological mysteries, including the elusive dark energy thought to drive the universe's expansion. They are, in short, the particles that could solve the universe. Which is why efforts to search for them are ramping up like never before.

A few years before his fateful walk, Wilczek was at the supermarket with his mother when he spotted a detergent called Axion. He liked the name. "When this opportunity arose for a new particle that cleaned up a problem, the stars were aligned," he says. "Weinberg had been calling it a 'Higglet', but he agreed that 'axion' was a better name."

> "There's no other way to solve the problems this particle addresses"

Axions, if they exist, would abide by the strange rules of quantum mechanics, meaning they could act as both waves and particles. As particles, they would have an exceptionally low mass, ranging from hundreds to billions of times smaller than the lightest particles we know of today. Because they would be so light, their wavelength could be as long as the width of a galaxy.

Not that axions were originally meant to be a solution to cosmological mysteries. Instead, the first issue they resolved was something called the strong charge-parity problem. This is a mystery in particle physics related to the strong force, one of the four fundamental forces. Unlike the other three, which affect matter and antimatter in different ways, the strong force affects subatomic particles called quarks to the same extent as their antimatter counterpart, antiquarks. But if there were some kind of new field pervading the universe, composed of light particles like axions, it could explain this unusual symmetry.

Then, in 1983, various physicists, including Wilczek, began to realise that this new kind of field could also solve another major problem. "It just came for free," says David Marsh at King's College London. This happened because, in the early universe, there was lots of energy. "As the universe cools, this [axion] field will start oscillating," says Marsh. In other words, it would give off energy in the form of pulsating light and heat. "The energy carried in those oscillations turns out to behave just like dark matter," he says. So axions became a candidate for dark matter.

Axions are good at hiding. This is mostly because they could come in a dramatically wide range of possible masses, so knowing where to look for them is tricky. As energy and mass are interchangeable, physicists measure the masses of particles using a unit known as an electronvolt, with the mass of a proton being a billion electronvolts. "The heaviest the axion could possibly be is about one-hundredth of an electronvolt,"

›

COLIN REID

**New Scientist audio**
You can now listen to many articles – look for the headphones icon in our app **newscientist.com/app**

says Marsh. “But it can go all the way down to one-trillionth of an electronvolt.” Because of this huge range of masses, nobody knew where to start. There was very subdued enthusiasm for axions, says Wilczek.

At the same time, an alternative explanation for dark matter had been gaining favour. Weakly interacting massive particles (WIMPs) were estimated to be much larger than axions, around the mass of the proton, which meant experiments to find them were easier to do. On the other hand, “the experiments to search for axions were really difficult”, says Marsh.

“For many years, WIMPs were dominant and axions got less attention,” says Ed Daw at the University of Sheffield in the UK. In the decades since WIMPs were proposed, however, there have been many searches for them, all of which have come up short. And over the past few years, research has suggested that, when it comes to dark matter, axions could make more sense than WIMPs. “They have essentially become the preferred dark matter candidate,” says Keir Rogers at the University of Toronto in Canada.

## Lumpy halos

One such hint comes from the way light bends around galaxies due to their gravity. Most galaxies are thought to be surrounded by halos of dark matter. We see this in the way they rotate, which appears to be uniform. From this, astronomers deduce that they must be pulled equally, in all directions, by some unseen force.

This is where axions come in. Their wavelength, the distance over which they oscillate, could be up to 3000 light years, says Lam Hui at Columbia University in New York. But like ripples in a pond, these oscillations would interact with each other, causing interference. In a dark matter halo, that might form noticeable regions of higher-density and lower-density axions. “It’s a very lumpy halo,” says Hui. Earlier this year, a team of astronomers led by Alfred Amruth at the University of Hong Kong found evidence for such a lumpy structure, in the way light bent around a galaxy on its way to Earth.

This is an exciting development, because if axions are the answer to dark matter, they could solve a separate, but related mystery. Namely, that dark matter appears to clump together less than we would expect. Observations of the cosmic microwave background (CMB), the light left over from the inflation of the early universe given off some 380,000 years after the big bang, don’t match up with the distribution of clusters of galaxies we see today.

“We have a model of the universe to predict how it should look right after the big bang and today, but those two observations don’t agree with each other,” says Catherine Heymans at the University of Edinburgh in the UK. Heymans was the first to spot this problem, known as the sigma-8 tension, and has worked on it for years. If dark matter were even partly composed of ultralight axions, meaning those at the lower end of the potential mass range, she says, these axions might suppress the clumping.

## All the answers

**Theoretical particles called axions could provide answers to two more mysteries in cosmology, on top of dark matter and dark energy (see main story). The first is the Hubble tension. This is the question of why, when we predict the acceleration of the expansion of the universe based on analysis of light left over from the big bang, known as the cosmic microwave background (CMB), we get a different rate to what we see when looking at the speeds of stars moving away from us locally. “Axions may alter the history of the universe,” says Francesca Chadha-Day at Durham University, UK. If certain kinds of axions existed in the early universe, they could change what we predict based on the CMB, removing the tension.**

**The second mystery is why there is anything at all. When the universe was born, matter and antimatter should have been made in equal amounts, annihilating to leave nothing. That didn’t happen, of course. And it turns out that a rotating axion field could explain the imbalance.**

NASA/JWST

**Axions could help explain dark energy, the force driving the universe apart**

Evidence for this could come soon, if we are lucky. Such axions might show up in experiments seeking to find gravitational waves, ripples in space-time caused by massive objects spinning or colliding. In June, a handful of experiments measuring the arrival times of light pulses from rapidly spinning stars, known as pulsar timing arrays, revealed the first evidence for a gravitational wave background pervading the universe. These waves turn out to be a great way to measure the distribution of dark matter in the cosmos, too.

“Oscillating axions would leave imprints in these gravitational wave signatures,” says Rogers. So far, the datasets aren’t sensitive enough to detect such imprints. “They didn’t find anything in the first run,” he says. But the results should continue to improve as more pulses are measured, narrowing down a potential signal of axion dark matter.

If detected, it is possible that axions make up all dark matter, solving the mystery in one swoop. But it could be that they comprise only a fraction of it, the rest being WIMPs or other candidates – things like primordial black holes left over from the big bang. “There’s no reason dark matter should be one thing,” says Marsh. “The standard model of the universe is very complicated, with protons, neutrons, quarks, electrons, all of them. Why should dark matter be simple?”

Axions themselves probably wouldn’t come in just one guise, either. It is likely that if one type of axion exists, then there is a range of them, from the ultralight to the relatively heavy, like a family of waves and particles, with each applicable to different problems. “It would be very natural to have axions of different masses,” says Francesca Chadha-Day at Durham University in the UK. “But we have to be wary of using that to say we’ve got an axion for every problem when we haven’t had any direct experimental evidence for them.”

Not yet, anyway. But an observation by the European Space Agency’s Planck satellite has provided some of the best evidence so far. And this time, axions might help solve a completely different mystery in cosmology by offering a potential explanation for dark energy, the unknown force causing the universe to fly apart.

In 2020, Yuto Minami at the High Energy Accelerator Research Organization in Japan and Eiichiro Komatsu at the Max Planck Institute for Astrophysics in Germany were looking at measurements of the CMB from the Planck satellite when they found something intriguing. They looked at a property called polarisation – a measure of light's orientation when it travels as a wave – and found it had rotated by a couple of degrees. It seemed as if something had interfered with the light between it being released and reaching the satellite.

What's even more intriguing, says Marsh, is that this strange effect had already been predicted decades ago. In the 1980s, researchers had been looking into the axion field and found that, as particles of light, or photons, moved through it, the field would cause them to interact with themselves. The polarisation of light detected by Planck is "very naturally explained by axions between the CMB and us detecting it", says Marsh.

It just so happens that the kind of axion being proposed would behave like dark energy, but only for a certain period of time. This makes it part of a class of dark energy known as early dark energy, so-called because it was only around in the early universe. There are lots of theoretical kinds of early dark energy, but this one is particularly strange: the axions would have acted like dark energy after the light of the CMB was released, interfering with it on its way to our telescopes. But then, at later times, they would have started to act like dark matter. "They behave a bit like dark energy and a bit like dark matter," says Marsh.

Axions offer potential explanations for a range of other mysteries, too (see "All the answers", left). But the Planck polarisation result is the most exciting, says Marsh. A Japanese space observatory called LiteBIRD, planned for launch in 2028, is specifically designed to measure the polarisation of the CMB. This will confirm whether the strange rotation is there or not. If the signal does hold up, these strange axions that behave like dark energy and then dark matter might exist. "We can try and search for them, and if we're lucky, they may be just below our current upper limits," says Marsh.

In the meantime, back on Earth, experiments to find axions are picking up pace. Arguably the best effort to date has been the Axion Dark Matter Experiment (ADMX) at the University of Washington in Seattle, which uses magnets to try to catch axions decaying into photons, which theory says they should do when influenced by a magnetic field. But this is a slow-burn approach because it requires a lot of measurements, says Gray Rybka, who leads the experiment. It is "like an AM radio", he says – but instead of a radio station, they are tuning for axions.

ESA

**Artist's impression of the path of light through the Planck satellite**

## Detections looming?

So far, ADMX, which has run since 1996, has explored only a small fraction, around 5 per cent, of the potential mass range of the axion. But the experiment continues to run and expand its search range, and a detection could come at any moment. "They could discover the axion tomorrow," says Marsh.

Other, smaller experiments are popping up too, taking advantage of the very trait that made axions so unappealing in the first place: their wide range of possible masses. At the University of Sheffield, for example, a new effort called Quantum Sensing for the Hidden Sector is set to begin a hunt for axions in 2024. The experiment can run colder than other axion searches, at close to absolute zero, says Daw, who leads the project. "That'll put us essentially in the quantum regime," he says. "We should be more sensitive than other experiments."

"There are now ideas to cover the entire mass range we think the axion could have," says Marsh. "It is very, very exciting." On the dark matter front, there is some competition between WIMPs and axions, says Laura Baudis at the University of Zurich in Switzerland. Searches for WIMPs continue, but the number of locations where they could be hiding gets smaller and smaller every year. For axions, many of the possibilities have yet to be explored. "There's a race between axion and WIMP experiments, but they're also complementary because they are not looking for the same particle," says Baudis.

If axions do turn up, they could clean up a whole number of messes with our universe. In that regard, they would truly live up to their detergent-inspired name. Wilczek, for one, is convinced that we will find them, eventually. "Theoretically, there's no other way to solve the problems it addresses," he says. "This particle more or less has to exist." ▮

Jonathan O'Callaghan is a freelance writer based in London

# Long covid, four years on

With millions of people affected by lingering symptoms after covid-19 infection, have we finally got a handle on this complex, post-viral condition and how to treat it, asks **Michael Marshall**

FOR many of us, the covid-19 pandemic is fading into memory. But for millions of people, that isn't possible as they are still unwell. An illness that is often brief and mild is, for some, the start of a rollercoaster of symptoms that can last years. Today, around 65 million people may have long covid.

That is the bad news. But around four years since the first cases emerged, evidence of the causes of long covid is rapidly accumulating, paving the way for treatments. Multiple trials of therapies are under way and several have already shown promising results. It is now also clear that people experience wide differences in their long covid symptoms, so treating this condition is an exercise in personalised medicine: no single approach will work for everyone.

Many questions remain, however. Can the plummeting levels of certain hormones explain the fatigue and brain fog, and is the persistence of the virus really key to understanding what is going on? And what should we do – and not do – to avoid developing long covid in the first place?

PETE REYNOLDS

The SARS-CoV-2 coronavirus started spreading around the world in early 2020. Within months, reports began emerging that some people were experiencing lingering symptoms. The term "long covid" was coined in May 2020 and widely adopted. The most common symptoms include headaches, brain fog and fatigue, or post-exertional malaise, in which even small amounts of activity cause exhaustion. Altogether, more than 200 symptoms have been reported, ranging from depression to gastrointestinal problems.

Since that time many things about this once mysterious condition have become clearer, but there is still a long way to go. For a start, the exact prevalence of long covid among people who have been infected with the virus remains uncertain. "The loose consensus would be roughly around 10 per cent," says David Putrino at the Icahn School of Medicine at Mount Sinai in New York. In a study from October led by Paul Elliott at Imperial College London that followed more than 242,000 adults, the median duration of symptoms of covid-19 infection was 1.3 weeks – in line with many previous analyses indicating that most people recover within a few weeks. However, 7.5 per cent still had symptoms after 12 weeks, and 5.2 per cent had them after a year.

On the other hand, a Swiss study that tracked 1106 unvaccinated adults who caught SARS-CoV-2 found that 22.9 per cent had long covid symptoms after six months, and 17.2 per cent still had them after two years.

Meanwhile, the cumulative burden of long covid continues to rise. Some 200 million people are predicted to develop the condition over the next decade, comparable with the number who currently have heart disease. However, the risk of long covid depends on the virus variant. Around 11 per cent of people infected with the older delta variant ended up with long covid, compared with 4.5 per cent of those who caught the more recent omicron variant that began circulating in late 2021.

It is now also clear that women are at greater risk of developing long covid than men, as are people who are unvaccinated (see "Reducing the risk", page 38) and those with pre-existing conditions such as asthma and rheumatoid arthritis. There is evidence of a genetic element too. For instance, variations in one region of the genome, close to a gene called *FOXP4* that is known to be important for lung function, were associated with 1.6-fold worse odds of developing long covid.

In short, it is a messy picture. And our understanding of the causes of long covid isn't much clearer. "There's no unifying theory yet," says Putrino. Instead, there are several working hypotheses, each with at least some evidence to support it, and it seems likely that different sets of mechanisms are at work in different people, perhaps with some overlap.

One of the most prominent, and controversial, ideas is that long covid is the result of abnormal particles in the blood, dubbed microclots. This hypothesis has been advocated by Resia Pretorius at Stellenbosch University in South Africa and her colleagues, who have described finding the particles in the blood of people with long covid and characterising their biochemical make-up. Furthermore, in a paper posted online in 2021, which doesn't seem to have been published ›

**in a** peer-reviewed journal, her team described using a set of three drugs to destroy the particles, resulting in a reduction of symptoms. As a result, people with long covid began travelling to private clinics to get treatments targeting the particles. Some received apheresis, which involves inserting large needles into veins to filter the blood. Others were given cocktails of drugs.

This caught the attention of Tilly Fox at the Liverpool School of Tropical Medicine in the UK and her colleagues. Fox specialises in producing systematic reviews for the Cochrane Collaboration, often considered the gold standard of evidence-based medicine. “We couldn’t really see where the evidence had come from to justify this treatment,” says Fox.

The result was a Cochrane review of the use of apheresis to treat long covid, and of the microclots hypothesis as a whole, published in July. “We first looked for any trials to see whether there was any evidence for the effectiveness and the safety of that treatment,” says Fox. They couldn’t find any controlled trials of apheresis for long covid. “That’s not completely unheard of,” she says, particularly for emerging therapies.

A second issue concerned the microclots themselves. “They weren’t true clots,” says co-author Rebecca Kuehn, also at the Liverpool School of Tropical Medicine. In medical terms, a clot isn’t any old particle in the blood, but rather a specific kind containing cells called platelets and proteins called fibrin or fibrinogen. The microclots had these proteins, but not the platelets: instead, they had another protein called amyloid. This means treatments that target traditional clots wouldn’t necessarily work.

However, other long covid researchers are following up on Pretorius’s work. For instance, Putrino has seen many people with long covid with microclots, and says that treatments targeting them seem to bring improvements. His team is now working on a rigorous analysis of the particles. The upshot is that a firm answer on microclots will only be had when studies have been repeated and validated.

> **“The incidence of long covid is predicted to reach that of heart disease”**

Meanwhile, there is a large body of evidence showing disruptions to the immune system in long covid. One possibility is that some people’s immune systems don’t respond correctly when first infected. In some studies, people with lower levels of antibodies against the coronavirus at an early stage of infection were more likely to develop long covid later. There is also evidence that some people with long covid have ongoing activation of their immune system. Other studies indicate that certain parts of the immune system remain overactive in people with long covid, while other parts are underactive. There is also some evidence of autoimmunity, in which the immune system attacks the body.

The difficulty is figuring out which of these immune disruptions are specific to long covid, what the causal mechanisms are and how they are linked to the various symptoms. Putrino and his colleagues took a step towards this in a study published in September. They profiled the immune systems of 275 people with and without long covid, then used a machine-learning algorithm to look for a “signature” of long covid. The team found a host of differences, from changes to populations of white blood cells to altered antibody responses. Patterns of two particular immune chemicals indicate “that the body is fighting something persistently”, says Putrino.

However, the biggest change in those with long covid was hormonal. These individuals had low levels of the hormone cortisol in the mornings. Cortisol has many functions, notably as a modulator of immune response, suppressing some immune functions and boosting others. It is also responsible for waking us up. “You expect to see peaking levels of cortisol in the morning, and what we saw were very flat levels of cortisol in this particular long covid cohort,” says Putrino.

The following month, similar immunological changes were reported by a team led by Julia Berentschot at the University Medical Center Rotterdam in the Netherlands. The researchers studied the immune systems of 37 people with long covid with fatigue and 36 with it but without fatigue, plus 42 people who had never had the condition. Those with long covid had more signs of inflammation and evidence that some of their white blood cells weren’t functioning correctly. In addition, those with more severe fatigue showed signs of chronic activation of white blood cells.

Co-author Hemmo Drexhage, also at the University Medical Center Rotterdam, says there is growing evidence that immune system disturbances can disrupt other bodily systems, including hormones and the brain – sometimes contributing to conditions like depression. “I see patients with severe depression after the infection and it fits completely with the idea that we had that there is a disturbed immune system in depression,” he says. If inflammation is at work in those with long covid, anti-inflammatory drugs could help, says Berentschot. Some such medications are being tested: for example, a German trial is investigating whether the anti-inflammatory methylprednisolone can reduce cognitive deficits in long covid.

Many of these studies of the immune system have uncovered signs of chronic overactivation, as if people with long covid are still fighting an infection. This has led many researchers to suspect that the explanation for the condition is disarmingly simple: the SARS-CoV-2 virus is still in their bodies.

Early in the pandemic, this idea was widely dismissed because the virus doesn’t show up in blood samples after the first few weeks. However, many now view that as a mistake. In a review published in September, Amy Proal at PolyBio Research Foundation in Massachusetts and her colleagues summarised evidence from biopsies and autopsies that the virus can persist in many tissues and organs, including the gut lining, skin and lungs. She says similar

## Reducing the risk

**Vaccination is a key factor in cutting the chances of getting long covid, as is resting as much as possible in the first two weeks of the initial infection. But most crucial is preventing infection in the first place and several things can help with this. Improved ventilation and purification reduce the number of pathogens around. When we do become sick, wearing face masks and staying at home can reduce the risk of passing on the disease.**

## Long covid in kids

**Early in the pandemic, it became clear that children were generally at lower risk from covid-19 than adults. This is also true for long covid – but there are still many children with the condition.**

**A recent study found that 1 to 3.5 per cent of children infected with the SARS-CoV-2 coronavirus went on to develop long covid, experiencing many of the same symptoms as adults, with older children at greater risk of this. Fortunately, many recovered: after 18 months, only around 1 per cent were still symptomatic.**

viral persistence has been seen in other post-infection conditions, such as post-Ebola syndrome. An added complication is that many people carry latent viruses anyway, notably herpesviruses that excel at hiding in our bodies. There is evidence that reactivation of these latent viruses can play a role in long covid, as well as in other chronic conditions such as myalgic encephalomyelitis, also known as chronic fatigue syndrome.

### Viral persistence

For Proal, viral persistence may be the key to long covid. "I see it as the upstream driver of most of those other things," she says. For example, a reservoir of virus could explain the chronic immune activation seen in some people. Furthermore, the virus's spike protein has been shown to cause clotting, so if this leaks out of the virus reservoir into the blood, it could explain microclots. Proal says that 30 to 60 per cent of people with long covid show the spike or other SARS-CoV-2 proteins in their blood.

Persistence of the virus can have widespread consequences. This was highlighted in a study from October led by Maayan Levy at the University of Pennsylvania showing that people with long covid tend to have low levels of serotonin, a neurotransmitter and hormone. The researchers then identified a complex chain of events behind this. Persistent virus led to chronic inflammation, which reduced serotonin levels by impairing the gut's ability to take up a crucial precursor found in food, reducing serotonin storage and increasing its turnover. The low levels of serotonin, in turn, affected the central nervous system – potentially explaining some of the cognitive symptoms in long covid.

For these people, a key part of treatment will be to suppress or eliminate the virus. Putrino and his colleagues are starting a trial in people with long covid of Paxlovid, an antiviral that blocks the action of one of the coronavirus's proteins. "It doesn't eradicate the virus, it just stops the virus from replicating," he says. Meanwhile, a study led by Michael Peluso at the University of California, San Francisco, will try to wipe out any remaining virus using a cloned, lab-made antibody.

"There are many clinical trials on the horizon," says Putrino. Notably, two medications have shown promise for preventing long covid when given soon after infection. A study from June showed that metformin, a drug used to treat type 2 diabetes, reduced the incidence of long covid after 300 days from 10.4 to 6.3 per cent. Similarly, a March study showed that Paxlovid also made long covid less likely.

Long covid researchers agree that a mix of treatments will be needed. "There's not going to be one single blockbuster long covid treatment," says Proal. What is needed, according to Peluso and others, is a moonshot effort: $10 billion over a decade to research long covid and other post-infection conditions.

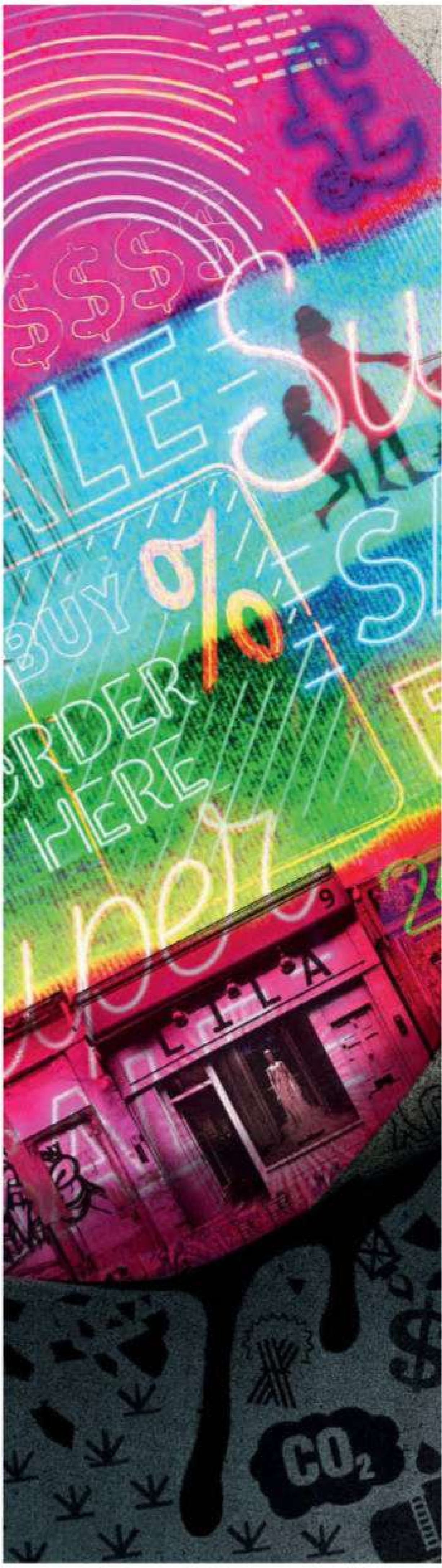
Such syndromes may be more common than suspected. Lingering symptoms have been seen in the wake of other diseases, including the 1918 influenza pandemic and many Ebola outbreaks. And according to a study from October, even common respiratory infections can cause long-term symptoms: in other words, some people experience "long colds".

All this highlights how far we have come in understanding the long-term aftereffects of viral infections. And while the complex picture of long covid that has emerged means that treatment pathways are likely to be complex too, researchers are cautiously optimistic. "I think the interventional landscape is certainly a lot more exciting and interesting than it was a year ago," says Putrino. ■

Michael Marshall is a science writer based in Devon, UK, and author of *The Genesis Quest*

# The hidden cost of everything

The cost of the goods and services we buy doesn't reflect the environmental and social damage they cause. That may soon change, discovers **Graham Lawton**



MARTIN O'NEILL

IN THESE difficult times, it seems utterly bananas to say that food is underpriced. In the UK, average grocery bills have risen by more than 12 per cent in the past year. But it is. The price tags on food are way lower – by about two-thirds – than what they would be if we were paying the full cost. Don't worry, though, there are plans to sort this out.

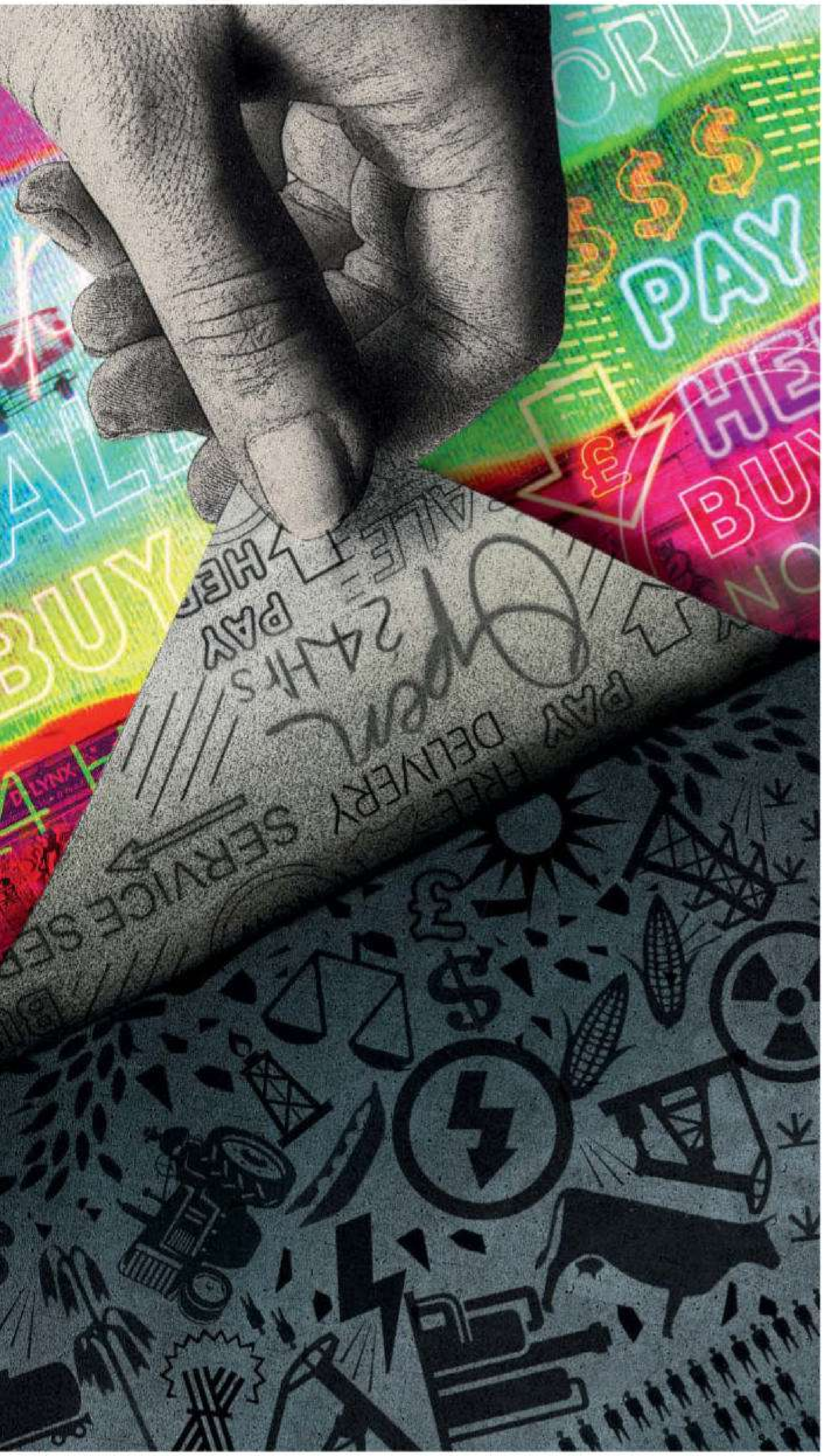
That might sound unpalatable: who wants their grocery bill to rise even more? Yet in reality, we already pay the true price, it is just that most of it is stealthily hidden from us. "We pay overall four times for our food," says Alexander Müller at the sustainability think tank TMG in Berlin. First, we pay at the checkout. Then we pay for the health, environmental and social costs of producing that food, mostly though taxes.

These costs are "externalities" – things that are treated as free even though they aren't, such as the environmental damage caused by farming or the health costs of obesity. Right now, producers ignore them and let the rest of us pick up the bill. Maybe not for much longer. Economists and accountants – don't yawn at the back! – have been working on a system called true cost accounting (TCA), which aims to internalise these externalities and upend decades of economic orthodoxy. Play our cards right, and it won't result in all of us spilling more cash at the tills, but rather in a wholesale recalibration of global supply chains that finally accounts for the actual cost of food and other goods.

For decades, economic success or failure has been measured in purely financial terms. Consider the global yardstick of economic progress, gross domestic product (GDP) – the value of all the goods and services produced in a country. The concept was invented in the 17th century, but became the internationally accepted indicator of economic success after the second world war. If GDP grows, the economy is deemed to be healthy, and GDP growth has long been an overriding priority of most governments.

But GDP contains some glaring absurdities. For example, it omits services provided by the state, such as healthcare. Unpaid work also doesn't count, even though it often displaces activities that, if paid for, would. Car accidents boost GDP because they stimulate economic activity in the insurance and repair sectors. Waste contributes to GDP as long as the discarded stuff was bought with money.

Worst of all, GDP keeps many aspects of economic activity entirely off the books – the aforementioned externalities, which the Organisation for Economic Co-operation and Development defines as "situations when the effect of production or consumption of goods and services imposes costs or benefits on others which are not reflected in the prices charged". Natural capital, such as trees, is invisible to the GDP system until it is destroyed and turned into products. Ditto environmental degradation, which largely doesn't attract any financial penalties in calculations of GDP. In fact, deforestation and pollution can positively contribute to GDP if they



generate economic activity. Health and social problems caused by industry are also swept under the carpet, even though somebody will eventually have to pay for them.

When we buy stuff – food, clothes, energy and so on – the price we pay often fails to reflect the full cost of producing, consuming and disposing of those goods and services across their entire life cycle. The price of a tank of petrol, for example, doesn't include the cost of dealing with climate change and the air pollution caused by its combustion products. The price of a pair of jeans doesn't reflect the social cost of producing them in a sweatshop and the environmental cost of growing the cotton, transporting the jeans halfway around the world and managing the landfill they will probably end up in. The price of food doesn't reflect the social cost of low agricultural wages, the environmental cost of soil erosion, water and pesticide use, and the health costs of obesity and other diet-related conditions.

These externalities are arguably one of the main causes of our myriad environmental and social problems. "Destruction of biodiversity costs nothing, therefore, let's destroy it," says Müller, who is a former assistant director-general of the Food and Agriculture Organization of the United Nations (FAO). "Polluting the atmosphere with $CO_2$ has no cost immediately. These ignored real costs are leading to a global crisis."

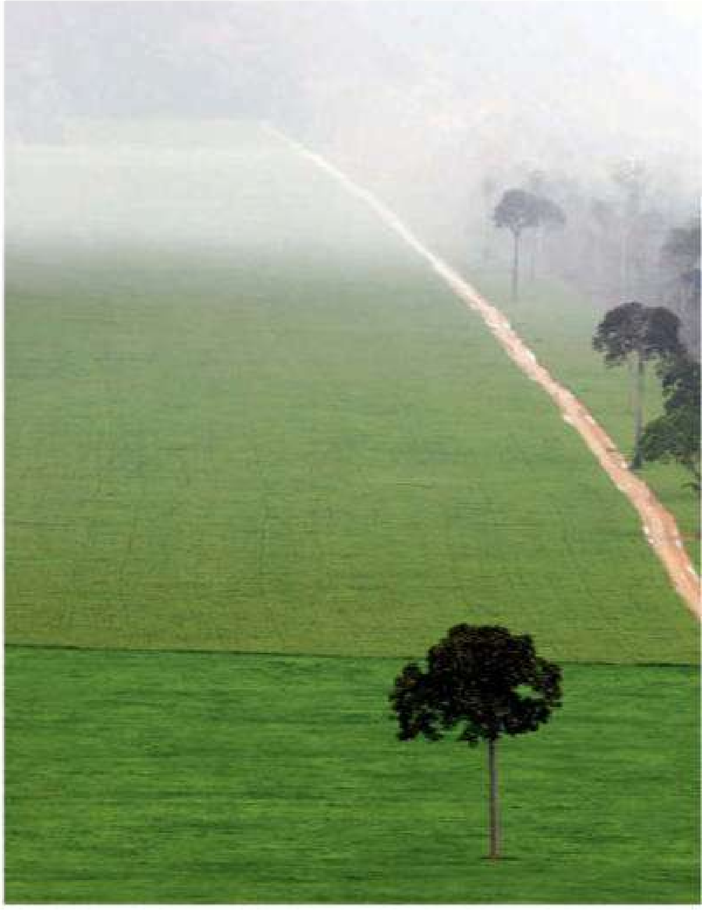
## Incentivising destruction

In today's economy, companies can deplete natural resources, pollute the environment, drive down wages and create harmful products, safe in the knowledge that they will reap the rewards while taxpayers pick up the tab. This is what is known as "privatised profits and socialised losses", according to Lauren Baker at the Global Alliance for the Future of Food in Washington DC.

Indeed, companies are incentivised to do so, as those that are more successful at externalising their costs will be more profitable, more competitive and better at raising capital for more of the same, says Baker.

This is where TCA comes in. It aims to capture all of the pluses and minuses that arise from economic activity, not just raw profit and loss. That means tallying up the cost of the environmental, human health and social harms (or benefits) of production and adding them to the balance sheet.

Until recently, that was almost impossible. ›


RICARDO BELIEL/BRAZIL PHOTOS/ALAMY

But years of progress on methodologies such as life cycle assessment, which tallies the full social, environmental and economic impact of products from cradle to grave, have made TCA tractable. Life cycle assessment has been in development for 50 years, but, until now, has been largely non-monetary. TCA is a way of converting life cycle assessment into cold, hard cash, says Ulrike Eberle at sustainability consultancy Corsus in Hamburg, Germany.

That is the goal: to create a globally accepted accounting system for the true cost of our economic activities. "It's absolutely vital," says Rebecca Henderson at Harvard University, author of the book *Reimagining Capitalism in a World on Fire*. "If you don't measure it, it's all just corporate speak. We need material, auditable, replicable measures that are simple to implement."

It is in food and agriculture that TCA has made the most progress. In 2018, a United Nations Environment Programme initiative called The Economics of Ecosystems and Biodiversity (TEEB) created a tool called the TEEBAgriFood Evaluation Framework, which includes a methodology for TCA. Snappy it ain't, but vital it is, enabling users to calculate the externalities of products.

The tool is already being used by various actors in the food and agriculture sector. Some food companies have embraced it to reduce their negative impacts on society and the environment. One example is Dutch chocolatier Tony's Chocolonely, which aims to charge the "true price" of its products (see "Shopping with true costs", left). Insurers are increasingly interested in TCA to assess their clients' future exposure to climate change and environmental breakdown, says Baker, and financial advisers use it to help socially and environmentally conscious investors. It is also attracting interest from other sectors, notably clothing and aquaculture, she says. But TCA must spread further and wider. "The concept needs to be applied to everybody, to all economic activities," says Müller.

The application of TCA is exposing some very troubling facts about the current economic system. Earlier this year, a team led by Sheryl Hendriks, then at the University of Pretoria in South Africa, published the first global assessment of the true cost of food. It doesn't make for mouthwatering reading. Right now, consumers spend a total of around $9 trillion a year on food. But if they paid for the externalities, that bill would rise to $29 trillion. Around $10 trillion of the extra is the health costs from diet-related cancers,

## Shopping with true costs

**In Amsterdam, a pioneering supermarket displays two different prices for its goods. One is the market price, as you would see in regular supermarkets. The other is the "true price", which factors in the environmental, health and social costs of the creation, consumption and disposal of the product.**

**Unsurprisingly, the true price is always higher than the market price. Customers can choose which price to pay: if they opt for the true price, the premium goes to environmental and social causes.**

**In the True Price Supermarket, which opened in 2020, bananas are sold at either the market price of €2.79 per kilo or the true price of €2.94 per kilo – a measly extra 15 cents per kilo to cover the social costs of low-wage farming and impacts on land, water and climate. But some products have a much bigger mark-up: a hot chocolate rises from €2.79 to €3.70 because of the real price of cocoa and milk.**

**These premiums reflect the true cost of these products, as evaluated by a methodology called true cost accounting (see main story). Even though making the consumer pay the "true price" isn't the actual goal of this accounting method, the movement is spreading.**

**Many other Dutch retailers have trialled true pricing, as has German discount store supermarket Penny.**

ALBERT HEIJN

**At some shops, the prices reflect the true cost of making the products**

The destruction of the Amazon rainforest isn't currently factored into the cost of soya

> **"Deforestation and pollution can inflate calculations of economic activity"**

diabetes and cardiovascular disease; most of the rest is from fixing environmental damage. "Cheap food is very expensive if you consider the externalities," says Müller.

Hendriks emphasises that the $20 trillion extra cost is only a rough estimate, and also that it is incomplete. "It doesn't include social externalities, such as underpayment of wages and child labour," she says. Nor does it include the health costs from obesity, though some of these will be captured by the three conditions in the analysis. When all this is factored in, that vast underpayment is likely to rise even higher.

Last month the FAO put a slightly lower price tag of $12.7 trillion on the hidden costs of food production in its annual *State of Food and Agriculture* report, which focused on TCA.

Does that mean we need to pay more for food? "If a consumer was to pay for those externalities, they would have to pay three times the market value of food," says Hendriks, now at the University of Greenwich, UK. "But that is not what we're promoting. We're not promoting that prices should go up to accommodate this." The point, rather, is to expose the extent of the externalities to raise awareness and drive change.

This is a misunderstanding that dogs the TCA movement – that it will push up prices at the checkout. "People say, 'You with your TCA, you want to make food even more expensive'," says Müller. "That's nonsense. We are applying the 'polluter pays' principle." That means the agribusiness and food companies would foot the bill, incentivising them to change their business practices so as not to go into the red.

Detractors who bleat about hard-pressed consumers having to pay more are simply defending the status quo so they can continue to externalise their costs, says Müller. And in any case, consumers are already paying – or will pay in the future – for those externalities. "Even today, we pay for it," he says. "Maybe future generations pay for it. Other regions pay for it, or a combination of everything. It is not that true cost accounting is inventing costs. We are only identifying already existing costs."

**$13 - $20 trillion**

Estimate of the hidden costs of agriculture, globally

"This argument, it drives me crazy. It is just an excuse for inaction," says Baker. "The cost of inaction is trillions of dollars."

Redirecting harmful subsidies would soften the blow. The world currently subsidises agriculture to the tune of $600 billion a year, says Müller, most of which props up unsustainable practices, such as factory farming and excessive use of pesticides. That money should be redirected to pay for the industry's externalities, he says.

Of course, we aren't going to transition to a TCA world overnight. "I'm lobbying for a phased approach: try to gain friends, try to win some companies who can benefit from true cost accounting," says Müller. "Otherwise, you're looking like people who have crazy ideas and will never be successful."

Those friends might be companies that have adopted a circular economy approach, where everything is reused, and can showcase their environmental credentials via TCA. Or they might be firms that want to assess their future risks and take pre-emptive action, perhaps on the assumption that consumers will increasingly punish companies engaged in environmentally destructive activities, or that their assets will become less valued as the world transitions away from unsustainability. "I think most of them have realised that they will have to do it sooner or later," says Müller.

But getting from where we are now to where we need to be will be difficult. "Right now, we have a lot of people on the starting line," says Baker, "but the short-term incentives aren't there and you really are penalised in the market right now if you're an early adopter." There needs to be legislation, she says, to force companies to move towards TCA.

There also needs to be institutional backing, and it is coming. At last year's COP27 climate summit in Egypt, Máximo Torero, the chief economist at the FAO, threw his organisation's weight behind TCA. "FAO is taking this extremely seriously," he said. "It's a huge challenge, and we are afraid, like many of you, but we are going to overcome our fear and we are going to do this."

That could be a catalyst for real change, says Müller. "We will have it in the heart of policies, we will have a debate about the concept. Then the field is prepared for in-depth discussion."

The drive to internalise externalities seems to be catching on more widely too. The way GDP is calculated changes every 15 years; the next iteration, in 2025, will reportedly include measures of sustainability and well-being.

The transition to TCA will be a long, hard slog, however. "The construction of GDP took many, many centuries," says Müller. Overturning such entrenched economic orthodoxy is a tough ask. But if we recognise GDP for what it is, the transition will be easier, he says. "GDP is a social construction. It's not a natural law like the speed of light, it's an agreement in society." ■

Graham Lawton is a features writer at *New Scientist*

# The back pages

**Puzzles**
Try our crossword, quick quiz and logic puzzle **p45**

***Almost* the last word**
What is the shortest parking space a car could get into? **p46**

**Tom Gauld for *New Scientist***
A cartoonist's take on the world **p47**

**Feedback**
Not so clap happy, plus stepping tech and disco stars **p48**

**Twisteddoodles for *New Scientist***
Picturing the lighter side of life **p48**

## Mathematics of life

# That's a wrap

A book is easy; Toblerone less so. But whatever the gift, maths will help ensure it is beautifully wrapped, says **Katie Steckles**

Katie Steckles is a mathematician, lecturer, YouTuber and author based in Manchester, UK. Follow her @stecks

WRAPPING gifts in paper involves converting a 2D shape into a 3D one, which presents plenty of geometrical challenges. Mathematics can help with this, in particular by making sure that you are using just the right amount of paper, with no wastage.

When you are dealing with a box-shaped gift, you might already wrap the paper around it to make a rectangular tube, then fold in the ends. With a little measuring, though, you can figure out precisely how much paper you will need to wrap a gift using this method, keeping the ends nice and neat.

For example, if your gift is a box with a square cross-section, you will need to measure the length of the long side, L, and the thickness, T, which is the length of one side of the square. Then, you will need a piece of paper measuring 4 × T (to wrap around the four sides with a small overlap) by L + T. Once wrapped around the shape, a bit of paper half the height of the square will stick out at each end, and if you push the four sides in carefully, you can create diagonal folds to make four points that meet neatly in the middle. The square ends of the gift make this possible (and deeply satisfying).

Similarly, if you are wrapping a cylindrical gift with diameter D (such as a candle), mathematics tells us you need your paper to be just more than π × D wide, and L + D long. This means the ends can be folded in – possibly less neatly – to also meet exactly in the middle (sticky bows are your friend here).

KATIE STECKLES

How about if your gift is an equilateral triangular prism? Here, the length of one side of the triangle gives the thickness T, and your paper should be a little over 3 × T wide and L + (2 × T) long. The extra length is needed because it is harder to fold the excess end bits to make the points meet in the middle. Instead, you can fold the paper to cover the end triangle exactly, by pushing it in from one side at a time and creating a three-layered triangle of paper that sits exactly over the end.

It is also possible to wrap large, flat, square-ish gifts using a diagonal method. If the diagonal of the top surface of your box is D, and the height is H, you can wrap it using a square piece of paper that measures a little over D + (√2 × H) along each side.

Place your gift in the centre of the paper, oriented diagonally, and bring the four corners to meet in the middle of your gift, securing it with one piece of tape or a sticky bow. This will cover all the faces exactly, and look pretty smart too.

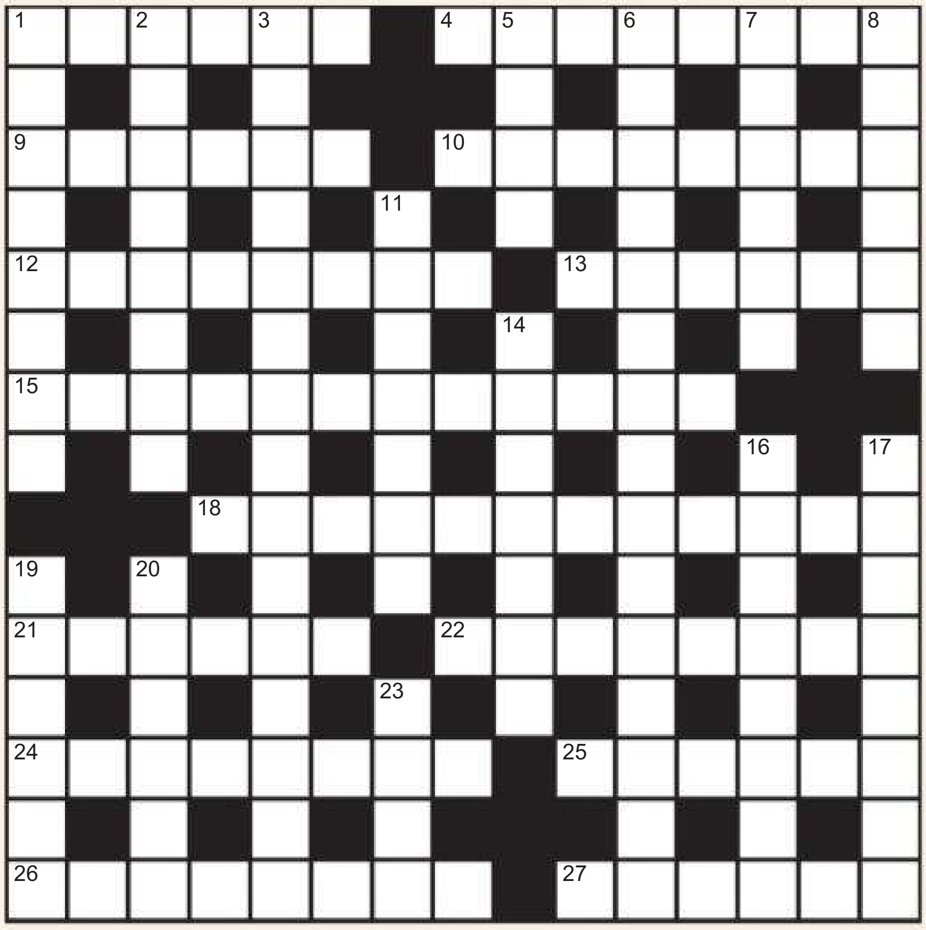
For maximum mathematical satisfaction, what you want is to get the pattern on the paper to line up exactly. This is easier for a soft gift, where you can squash it to line up the pattern, but will only work with a box if the distance around it is exactly a multiple of the width of the repeat on the pattern. Otherwise, follow my example (above) and get your own custom wrapping paper printed! ▮

**Watch Katie expertly wrap her gifts at youtu.be/s1yYk9_zlKc**

*Mathematics of life reveals the mathematical ideas and shortcuts behind everyday situations*

**Next week**
Debunking gardening myths

## Quick crossword #147 *Set by Richard Smyth*



**Scribble zone**

Answers and the next cryptic crossword next week

**ACROSS**

**1** 1985 sci-fi comedy-drama directed by Ron Howard (6)
**4** Digestive organ and gland (8)
**9** E (6)
**10** Genus of plants, widely used in traditional medicine (8)
**12** The S in AAA&S (8)
**13** Alloy of Cu and Sn (6)
**15** Obsolete communication facility (9,3)
**18** Students of the universe (12)
**21** Flightless New Zealand parrot (6)
**22** Eight-sided shapes (8)
**24** Posts designed to restrict traffic (8)
**25** Benign tumour (6)
**26** ___ process, steel manufacturing method (8)
**27** Linear configuration of celestial bodies (6)

**DOWN**

**1** Byproduct of tar distillation (8)
**2** Type of furry yarn (8)
**3** Compound with the general structure $O{=}P(OR)_3$, where R represents the variable part of the molecule (15)
**5** Curved architectural structure (4)
**6** Average location of an object's weight (6,2,7)
**7** $C_2H_6$ (6)
**8** Network; process (6)
**11** Units of 1,000,000 Ω (7)
**14** Behave like a mirror, for example (7)
**16** The study of smell (8)
**17** Equilibrium between Earth's crust and mantle (8)
**19** Bicycle-like form of snow transport (6)
**20** Head bones (6)
**23** Side (4)

**Our crosswords are now solvable online**
newscientist.com/crosswords

## Quick quiz #230
*set by Bethan Ackerley*

**1** Who was the first Jewish woman in space?

**2** The physical law stating that an electric current produces a magnetic field is known as what?

**3** What is the smallest known bird?

**4** The word "quark" is taken from which novel?

**5** Who is credited with coining the terms gene, phenotype and genotype?

*Answers on page 47*

## Headscratcher
*set by Howard Williams*

### #250 Are we nearly there yet?

**"How much further?" asks my son Jack, from the back seat of the car. It's a relief to have a variation, as all I've heard from him in the past hour is "are we nearly there yet?". If I'm not to go crackers, I need to give him something to occupy his mind.**

**So in answer to his question, I say, "Jack, an hour and a half ago we were a three-digit number of miles from our destination, with the middle digit being a zero. Three-quarters of an hour ago we had a two-digit number of miles still to travel, with its first digit being the same as the last digit of the three-digit distance and its second being the same as the first digit of the three-digit distance. We now still have a two-digit number of miles to travel, but its digits are the reverse of the previous two-digit number. As we are travelling at a constant speed, you should be able to calculate how many minutes it will take for us to arrive."**

**Silence reigned for at least 10 glorious minutes. Can you work out the answer?**

*Solution next week*

## Squeezing out

**What is the shortest space a parked car can get out of? Or a parking car can get into?**

***Hillary Shaw***
*Newport, Shropshire, UK*
Since cars are essentially rectangular, the very shortest space a car can theoretically enter or exit, by Pythagoras's theorem, is the diagonal from one front corner to the back corner on the opposite side, so 4.47 metres for an average car of 2 × 4 metres.

However, at this diagonal point, the (for example) left rear corner of the car is touching the kerb, the right rear corner is touching the car behind, the front left corner is touching the car in front and you have no space to manoeuvre to get fully in. Geometrically, if the car could rotate, you would need the same 0.47 metres at the front to swing the car fully in, total space required 4.94 metres. However, car wheels on an axle cannot physically turn by 90 degrees, so even this 4.94-metre space would require an approaching-infinite-point turn to enter. You can spend approaching eternity to get in that space, or look for another space of maybe 5.5 metres.

> **"It is possible to shift an adjacent car by shunting, but I don't think this method is approved in the UK Highway Code"**

It is also possible to shift an adjacent car either by shunting or simply by nudging up and using your engine to overcome the other car's brakes. But I don't think this parking method is approved in the UK Highway Code.

***Chris Maynard***
*London, UK*
Assertion: the smallest space a parking car can get into is 8 centimetres less than its length. Evidence: my wife and I were in a bar in Paris, sat facing the street. A woman pulled up to a space shorter than her Renault and backed into it. As her bumper touched the car behind, she accelerated until the parked car's bumper crumpled – as did hers. She then drove forward and did the same again, got out, locked the car doors and disappeared into an apartment block. Finishing our negronis, we walked along counting crumpled bumpers. None was untouched.

***Jeff Stanton***
*Sydney, Australia*
To park a car requires a series of "s"-shaped mirror image movements of the front wheels while moving backwards and forwards to manoeuvre the rear wheels near the kerb. With patience, this can probably be done with 50 millimetres or less of spare space. But in practice, things like the road's camber, the steepness of a hill, manual transmission, no power steering, an unseen towing ball on the car in front and the patience of the traffic held up behind the parking car will add degrees of difficulty to the task.

On the other hand, performing the manoeuvre in front of a shop with a plate glass window will let you watch the reflection and make the best use of the space.

In practical terms, a space about 300 mm longer than the diagonal of the car seems about the limit.

***Eric Kvaalen***
*Les Essarts-le-Roi, France*
Mathematically speaking, there is no shortest space. As long as the space is longer than the car, it is theoretically possible to get in or out of it by doing a large number of back-and-forth movements. Provided the difference between the length of the space and the length of the car is positive, it is possible. If the difference is zero, it is impossible. So, the question is like asking what the smallest positive number is, and the answer is that there is no smallest positive number.

***Tony Durham***
*Brighton, UK*
The shortest space you could drive straight into or out of would have to be at least the diagonal dimension of the car. How closely this limit can be approached may depend on how tightly the vehicle can steer.

To escape from shorter spaces, you have to drive forwards and backwards repeatedly, while applying out-of-phase wiggles to the steering. Those lucky enough to understand alternating current circuit theory may see analogies here. Unparking is a lot like getting electrons to do useful work while they shuttle back and forth within the same piece of wire.

In shorter spaces, the required number of iterations tends to infinity and the margin of error tends to zero. But, in theory, you can escape from any space longer than the vehicle.

By performing the same actions backwards, in principle, you could park in a space barely longer than your car. But most drivers try to avoid having to do that. You can't choose the new configuration of cars in the place you parked 4 hours ago, but you can choose where you will park right now. My rule of thumb is to find a space at least 50 per cent longer than the car.

***David Pitcher***
*Auckland, New Zealand*
I have always found that if I want to parallel park in one move, the

BRETT STEVENS/CULTURA CREATIVE RF/ALAMY

Why does reheated food always taste better than the original meal?

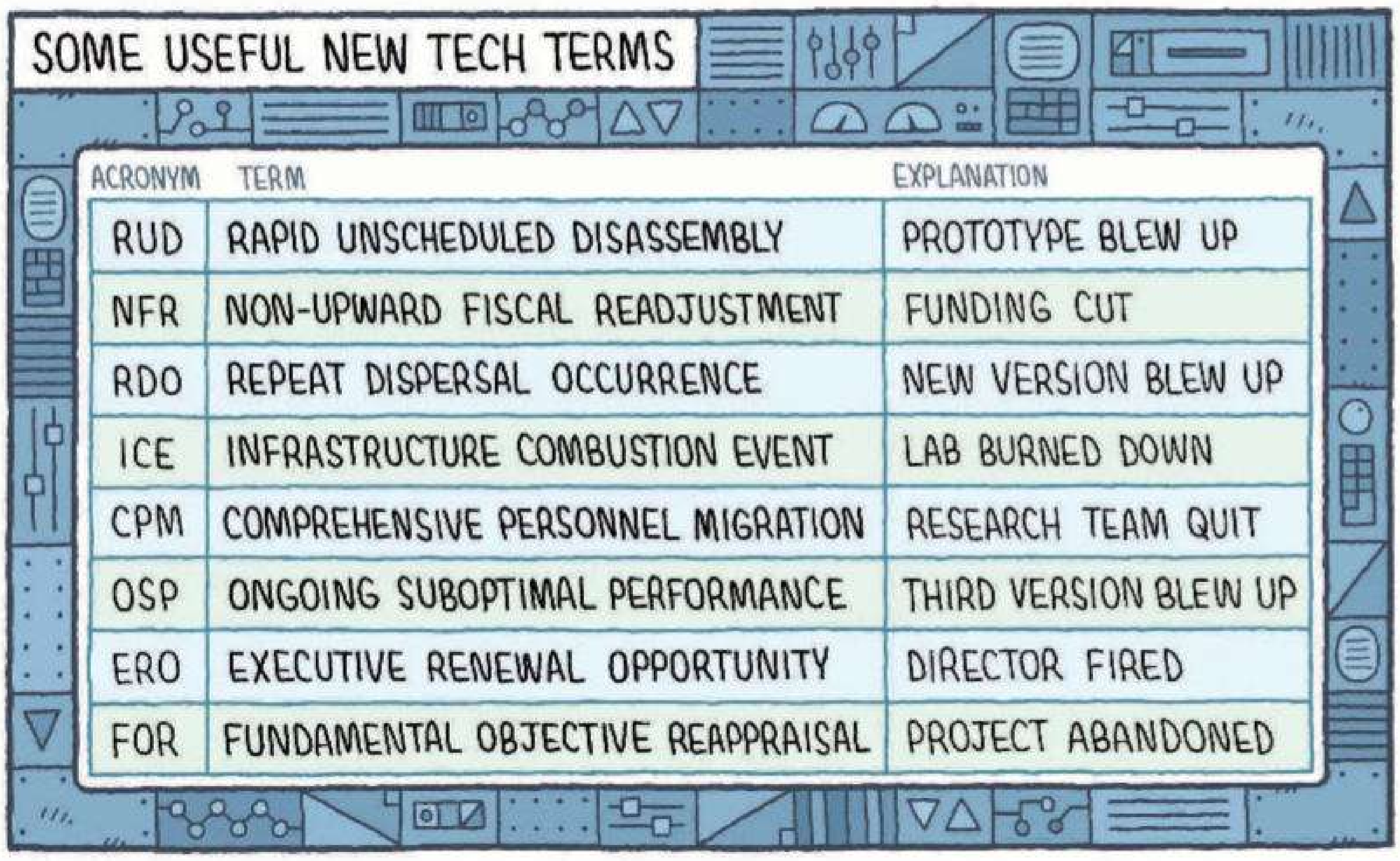
### This week's new questions

**Enough for tomorrow** **Why are leftovers from a hot meal always tastier than the original meal when they are heated up the next day?** ***Kevin Halford***, *Pelt, Belgium*

**Forgotten it all** **Could we survive complete memory loss? If we could, would we revert to the state of a newborn baby?** ***John Howes***, *Cardiff, UK*

**Want to send us a question or answer?**
**Email us at lastword@newscientist.com**
**Questions should be about everyday science phenomena**
**Full terms and conditions at newscientist.com/lw-terms**

## Tom Gauld
*for New Scientist*



SOME USEFUL NEW TECH TERMS

| ACRONYM | TERM | EXPLANATION |
|---|---|---|
| RUD | RAPID UNSCHEDULED DISASSEMBLY | PROTOTYPE BLEW UP |
| NFR | NON-UPWARD FISCAL READJUSTMENT | FUNDING CUT |
| RDO | REPEAT DISPERSAL OCCURRENCE | NEW VERSION BLEW UP |
| ICE | INFRASTRUCTURE COMBUSTION EVENT | LAB BURNED DOWN |
| CPM | COMPREHENSIVE PERSONNEL MIGRATION | RESEARCH TEAM QUIT |
| OSP | ONGOING SUBOPTIMAL PERFORMANCE | THIRD VERSION BLEW UP |
| ERO | EXECUTIVE RENEWAL OPPORTUNITY | DIRECTOR FIRED |
| FOR | FUNDAMENTAL OBJECTIVE REAPPRAISAL | PROJECT ABANDONED |

length of the vehicle plus its width is the smallest space I can get in. If I am boxed in, having half the width free is a minimum, but it takes three or four tries (and a reversing camera) to extricate myself without hitting the vehicles in front or behind me.

***Patrick Forsyth***
*Maldon, Essex, UK*
Many years ago, when I was at school, a favourite trick was to get a gang of pupils together and lift a master's Mini, wedging it between two trees. You only needed a couple of centimetres each end to get it in, but it could only be got out by more lifting. I think cars are heavier these days.

## Deep dive

**Why don't marine mammals like whales get "the bends"? (continued)**

***John Davies***
*Lancaster, UK*
A previous correspondent explained why whales don't get the bends, and went on to describe how the bends were first encountered as caissons disease, ascribing this to deep hard rock mining. He was wrong.

> **"The world's deepest mine stretches to around 4000 metres below the surface. Its miners don't experience the bends"**

Air pressure varies by about 0.8 kilopascals per 1000 metres. The world's deepest mine, Mponeng gold mine in South Africa, stretches to around 4000 metres below the surface, so the pressure at the bottom would be 104 kPa, rather than the 101 kPa at sea level (although the mine entrance is actually at 1500 metres altitude). The miners don't experience the bends.

A caisson is a closed cylinder on the seabed, pressurised to keep the water out. It was used when mining had to be done underwater, for instance to build a bridge. A caisson's pressure must be equal to or just greater than the water pressure where the caisson's lip touches the bottom.

The deepest caissons were used to build the Tokyo Harbour Bridge in Japan, in water 46 metres deep, so the pressure inside must have been at least 5 atmospheres! A diver could stay there for less than 10 minutes, but could surface safely with only a precautionary stop for 3 minutes at 5 metres depth.

***John Healey***
*Adelaide, Australia*
A caisson wasn't a miner in a hard rock mine. *Caisson* is French for "coffer" or "chest". The word refers to the large box, watertight at the top and sides, that was lowered into deep water and used in the 18th and 19th centuries in laying the foundations of bridges.

It was open at the bottom, so air pumped into it was at a pressure equal to the surrounding water. Workers in this box were thus breathing compressed air and experienced the bends on getting back to the surface. The earliest reference to caisson in the *Oxford English Dictionary* is from 1753. ▮

## Answers

### Quick quiz #230
*Answers*

**1** Judith Resnik, in 1984
**2** Ørsted's law
**3** The bee hummingbird (*Mellisuga helenae*)
**4** *Finnegans Wake*
**5** Wilhelm Johannsen

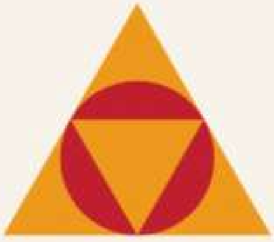
### Cryptic crossword #123 *Answers*

**ACROSS 1** Pinwheel, **5** Scam, **9** Butterfly, **10** Moa, **11** Swap, **12** Decanted, **13** Needle, **15** Condor, **18** Nacreous, **20** Stir, **23** Big, **24** Andromeda, **25** Tore, **26** Galaxies

**DOWN 1** Pubis, **2** Nitrate, **3** Heed, **4** Eiffel, **6** Comet, **7** Meander, **8** Dynamo, **13** Nanobot, **14** Leeway, **16** Dotted i, **17** Tundra, **19** Cigar, **21** Reaps, **22** Toga

### #249 Espresso geometry
*Solution*

Three more pots will be needed. This is easy to see if you rotate the smaller triangle so that it is upside down. The larger triangle is four times the size of the smaller one.



## Best interests at heart?

**Feedback is fascinated by the final eight words in this statement: "Disadvantages include the competitive element associated with racing, which creates a strong incentive to kill birds where this is not in their best interests."**

**The statement appears in a study called "The ethics of pigeon racing" by Jan Deckers and Silvina Pezzetta, both at Newcastle University in the UK.**

## Clap for the man

To learn how to treat gonorrhoea in people (rather than, say, in mice), scientists want to study a new infection from its very earliest moments.

The only real way to do that is to deliberately, aforethoughtfully infect a patient. Marcia Hobbs and Joseph Duncan at the University of North Carolina at Chapel Hill did the uncomfortable work of creating a protocol for how to infect a man with gonorrhoea. (The protocol specifies that "Experimental gonorrhea is restricted to male subjects; women are excluded due to potential reproductive complications from ascendant gonococcal infection".)

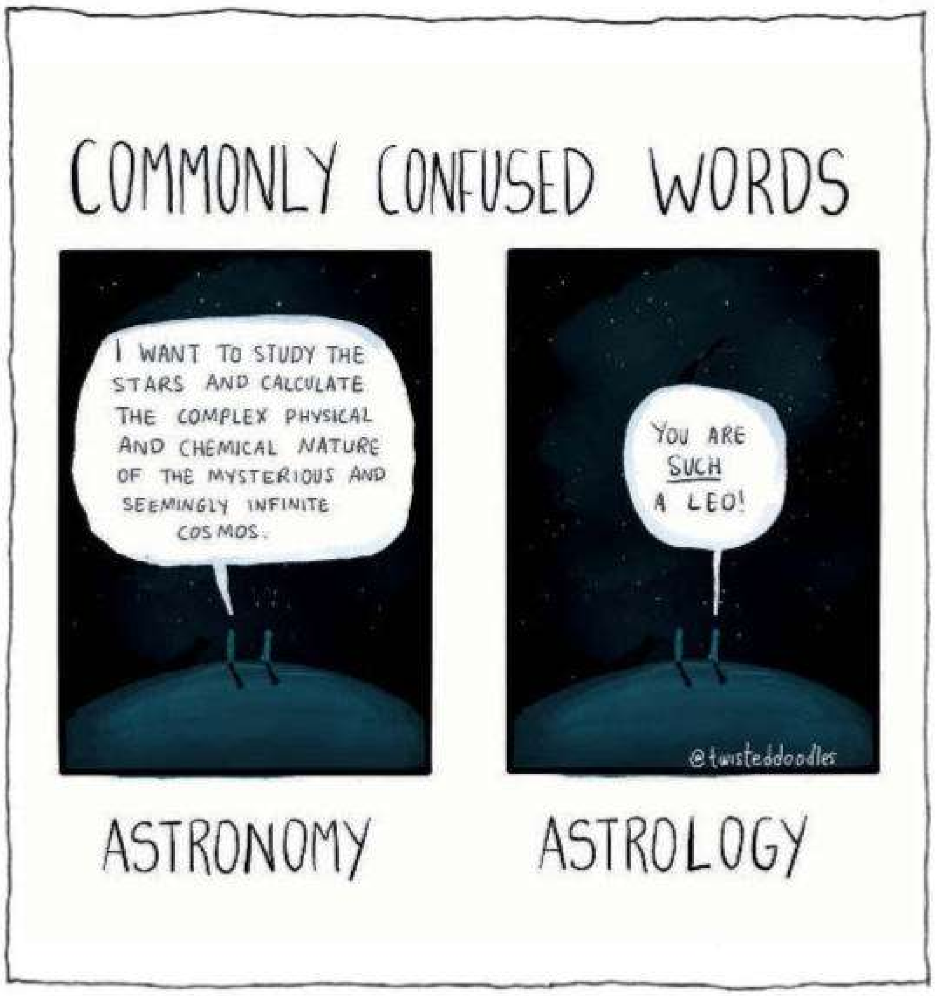
Shelley Petersen alerted Feedback to the protocol, which was published in 2019.

Reading through the early sections, Feedback felt the kind of foreboding that mounts slowly, slowly, as a horror movie approaches the actual, dreadful event. Then, suddenly, came the moment:

"3.4 Inoculation Procedure: Recline the subjects on a hospital bed, and ensure that they don sterile gloves immediately before inoculation. Cover the pelvic area with a waterproof plastic drape, and extend the penis through a hole in the drape and cleanse with 70% (v/v) isopropanol wipe. Remove a No. 8 pediatric French catheter, cut to 8 cm in length, from its sterile pouch, holding it between the cut opening and the 5 cm mark. Dip the closed end of the catheter into a container with sterile saline to moisten. This is inserted gently by the physician into the urethra until the 5 cm mark on the catheter is just visible at the opening of the urethra."

Feedback will not spoil here whatever is left to be spoiled.

## Twisteddoodles *for New Scientist*


COMMONLY CONFUSED WORDS
I WANT TO STUDY THE STARS AND CALCULATE THE COMPLEX PHYSICAL AND CHEMICAL NATURE OF THE MYSTERIOUS AND SEEMINGLY INFINITE COSMOS.
YOU ARE SUCH A LEO!
@twisteddoodles
ASTRONOMY
ASTROLOGY

**Got a story for Feedback?**
Send it to feedback@newscientist.com
or New Scientist, 9 Derry Street, London, W8 5HY
Consideration of items sent in the post will be delayed

## No wait for weight

**The next step in shoe technology promises good news for obsessive weight watchers. Or bad news. Lots of news, anyway, supplied continuously.**

**Foram Sanghavi and her team at Tufts University in Massachusetts envision a stream of data emanating from each foot as a person strides, strolls or ambles along – or stands or sits – providing that the person is wearing shoes. Shoes with special sensors.**

**Their paper, called "An individualized machine learning approach for human body weight estimation using smart shoe insoles", appears in the journal *Sensors*. The stated aim is to "achieve accurate real-time monitoring systems for estimating continuous body weight changes".**

**The task isn't easy. Others have taken imperfect steps towards taking useful, accurate data from steps. The paper makes unflattering mention of "poor experimental setups and data collection strategies" and "non-robust data analysis and evaluation methodologies" in some of the research that preceded the researchers' own.**

**The road to success has been bumpy. Bumpy roads are themselves part of the difficulty, potentially causing consecutive footsteps to produce strong variation in the output of a shoe insole sensor.**

**Many people have "unique postures, pressure points, and gait patterns". Fatigue and postural instability can monkey with anyone's gait.**

**The Tufts researchers, with "over 2200 shoe insole sensor measurements collected from 60 participants" under their belt and new artificial intelligence software in their lab, exude optimism about becoming able to accurately, continuously estimate a shod person's heaviness while the person goes through their idiosyncratically normal daily range of standing, sitting and walking – regardless of whether they saunter, pace, limp, lurch, lounge, sashay, skulk or mosey.**

## Cheap disco astronomy

You – yes, little (compared with the sun) you – can make your own sun spots. Robert Cumming and a team of scientists in Sweden, Germany, the Netherlands, Switzerland and France teach how to do it in a paper called "Why every observatory needs a disco ball", which they have submitted to the journal *Physics Education*.

Disco balls are also called mirror balls. The paper explains that "Disco balls are collections of what are known as pinhead mirrors, each the reflective equivalent of a pinhole camera aperture." What's more, "consisting of hundreds of small mirror segments, [they] are readily available at remarkably low prices".

With little effort and minimal danger, a disco ball can reflect light from the sun, projecting tiny, "mildly defocused" images of it all over the surfaces of the room.

Buyer alert! Some disco balls – even expensive ones, the researchers warn – are made from back-coated mirrors, which produce annoying "ghost" images.

Disco astronomy, if you will, on the cheap, bringing new stardom for our star, with 1970s ambience. ▮

*Marc Abrahams*

GALAXY
ON GLASS

SPECTACULAR WALL ART FROM
ASTROPHOTOGRAPHER CHRIS BAKER

GALLERY SALE

See the great deals available on all artworks displayed at New Scientist Live. Discounts of up to 25%!

www.galaxyonglass.com
chris@galaxyonglass.com | +44 (0)7814 181647

Nutmeg.
a J.P.Morgan company

Investing in trends,
made simple

Nutmeg's new Thematic portfolios are globally diversified and expertly managed for you.

nutmeg.com/trends

Capital at risk. Thematic investing carries specific risks and is not for everyone.

boring money
Best Buy
ISA
2023

YourMoney.com
INVESTMENT AWARDS
WINNER 2023

Download on the
App Store

GET IT ON
Google Play